Tevatron Collider Overview

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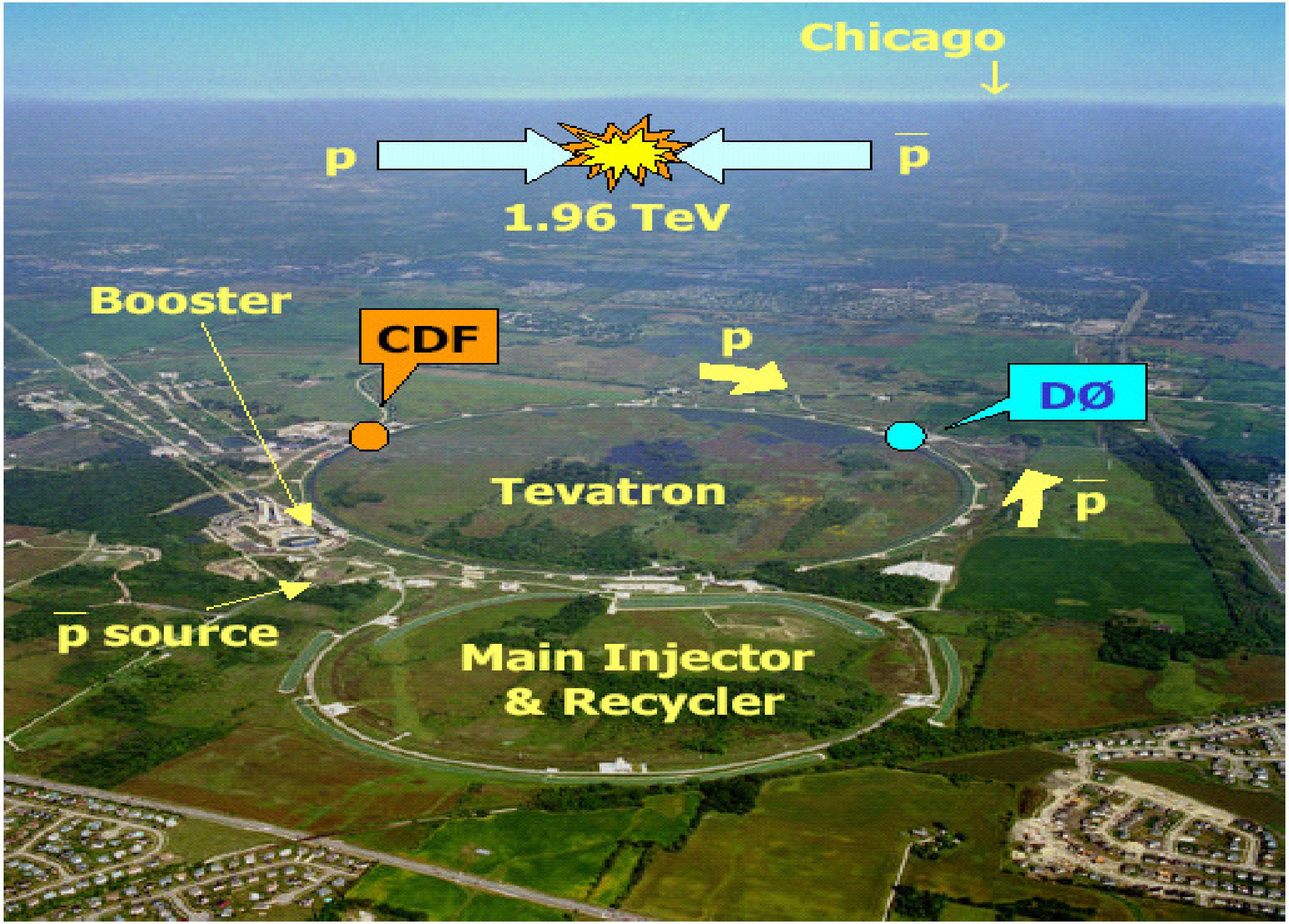
With the help of many D0 and CDF colleagues

More than just a Collider..

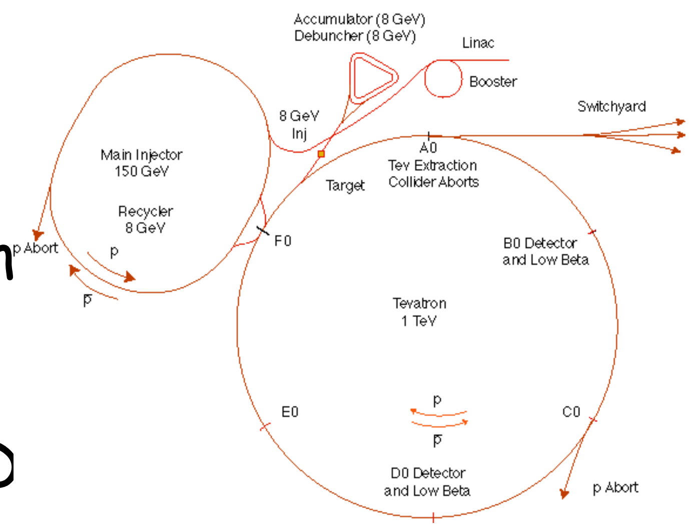


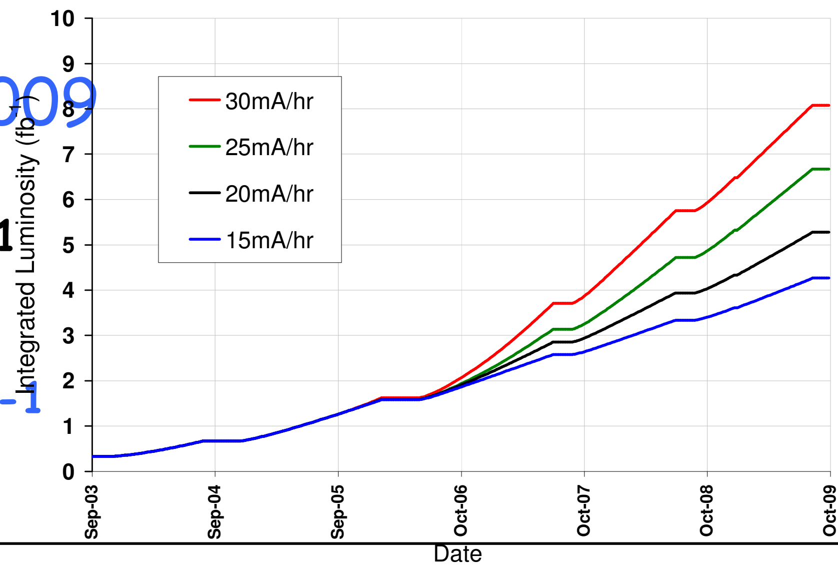
Tevatron- Introduction

The Tevatron collider is an ensemble of accelerators.

- "Run II is not a construction project. Run II is a complex campaign of operations, maintenance, upgrades, R& D and studies." (D.Lehman)
- Luminosity goal:
  - ⇨ 4.4-8.5 fb^{-1} by FY 2009
    - → More later
- Record: $2.9\times10^{32} cm^{-2}s^{-1}$
  - ⇨ Keep improving
  - ⇨ In one week 44.8 pb^{-1}
    - → record

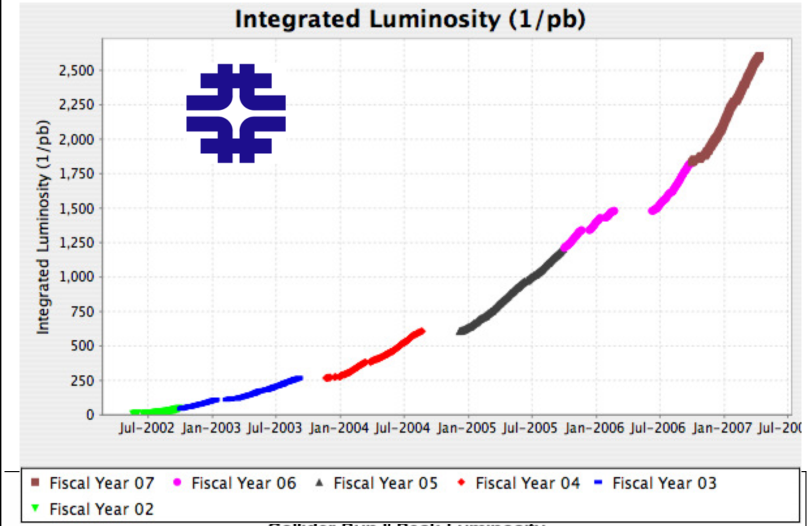
FermilabTevatron Accelerator With Main Injector

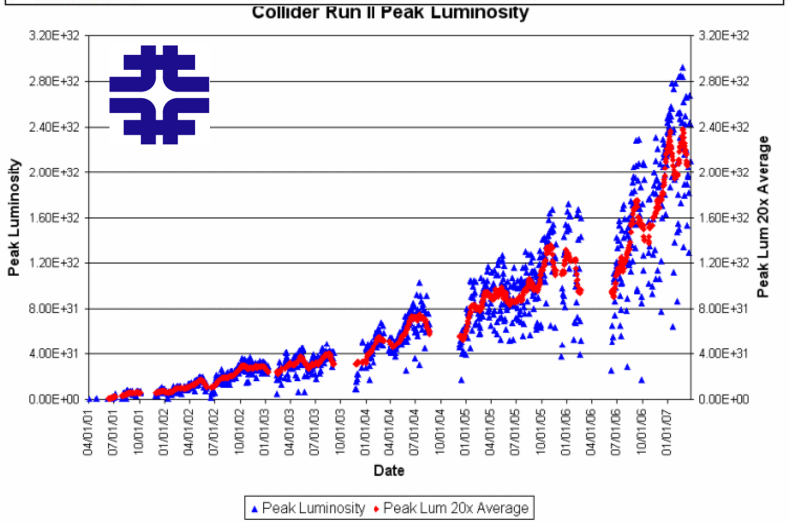




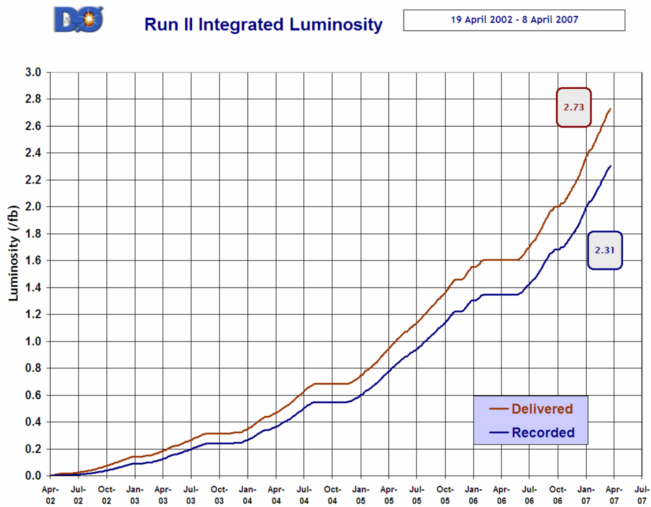
Data taking…2.9x10^{32}…

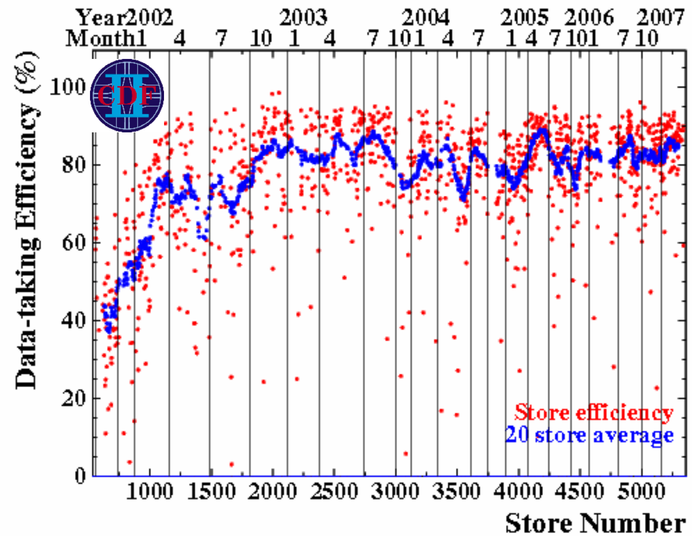
Accelerator delivers..





Detectors use:





Giorgio Chiarelli, DIS 07

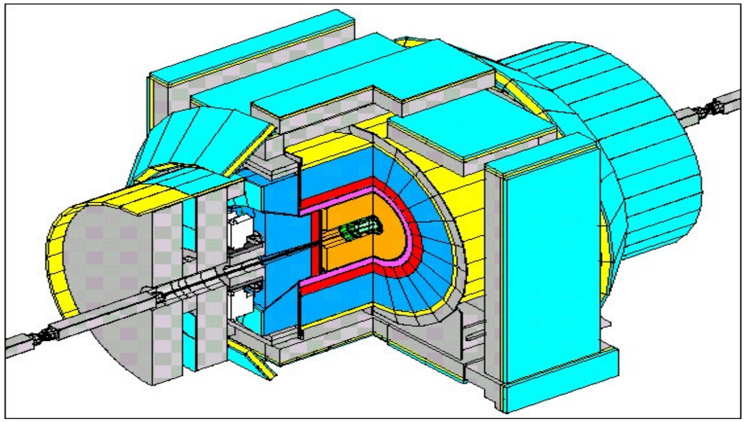
Two detectors

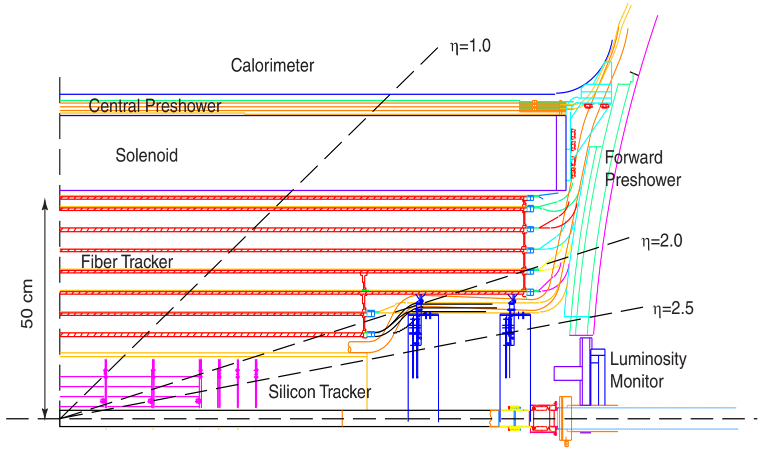
CDF underwent serious upgrades:

- New tracking system
  - COT, new silicon tracker (6-7 layers DS+1 SS)
- New forward calorimetry
- Tracking at trigger level
  - Tracks at L1
  - Displaced from PV@L2

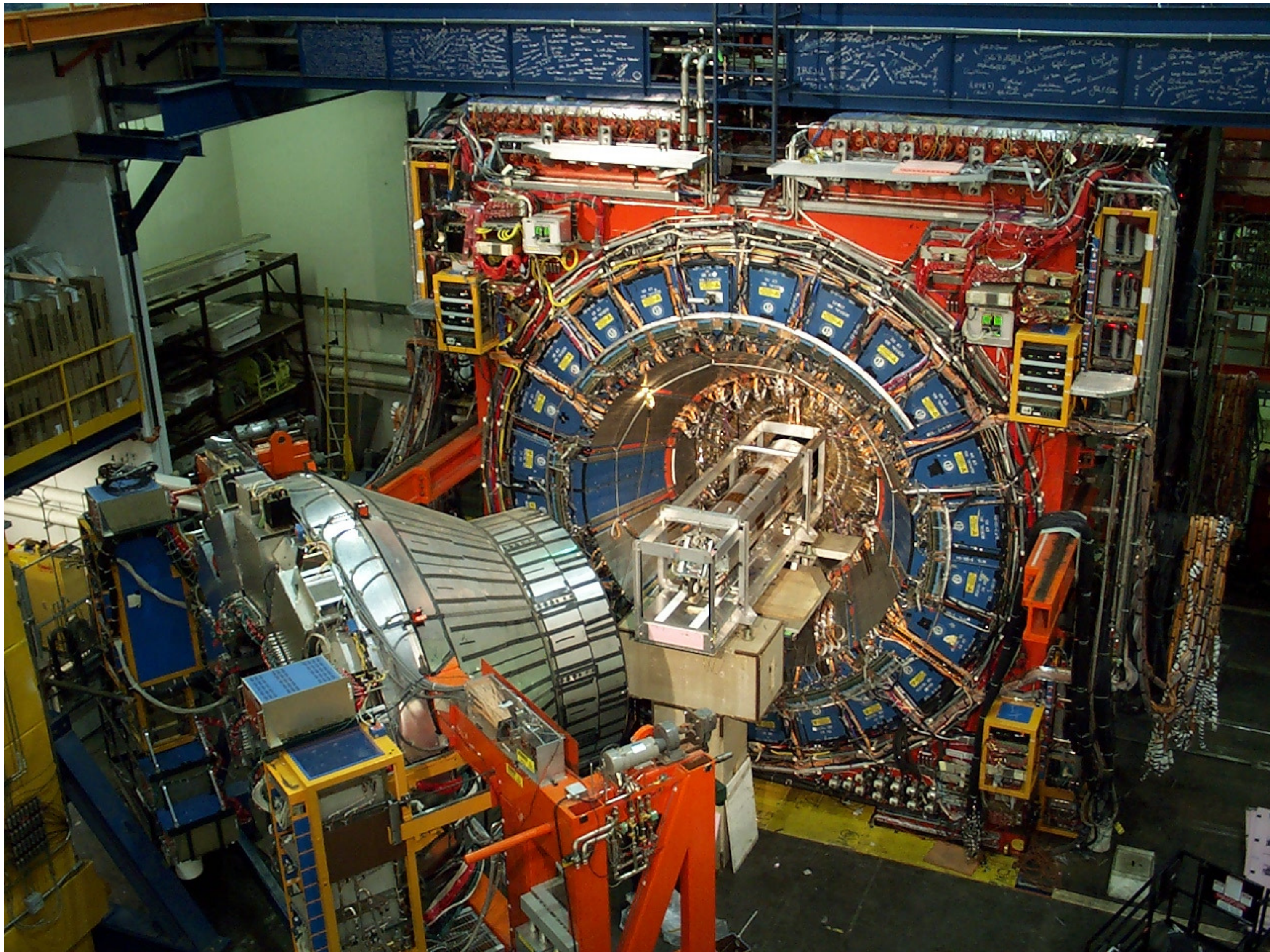
D0: change of philosophy

- New tracking system
  - Based on a 2T solenoid
  - New 8 layers fiber tracker
  - Secondary vertices capability (SVX)
  - Recently added (IIb) an extra layer of silicon sensors
- Improved muon coverage
- Upgraded trigger (IIa, IIb)

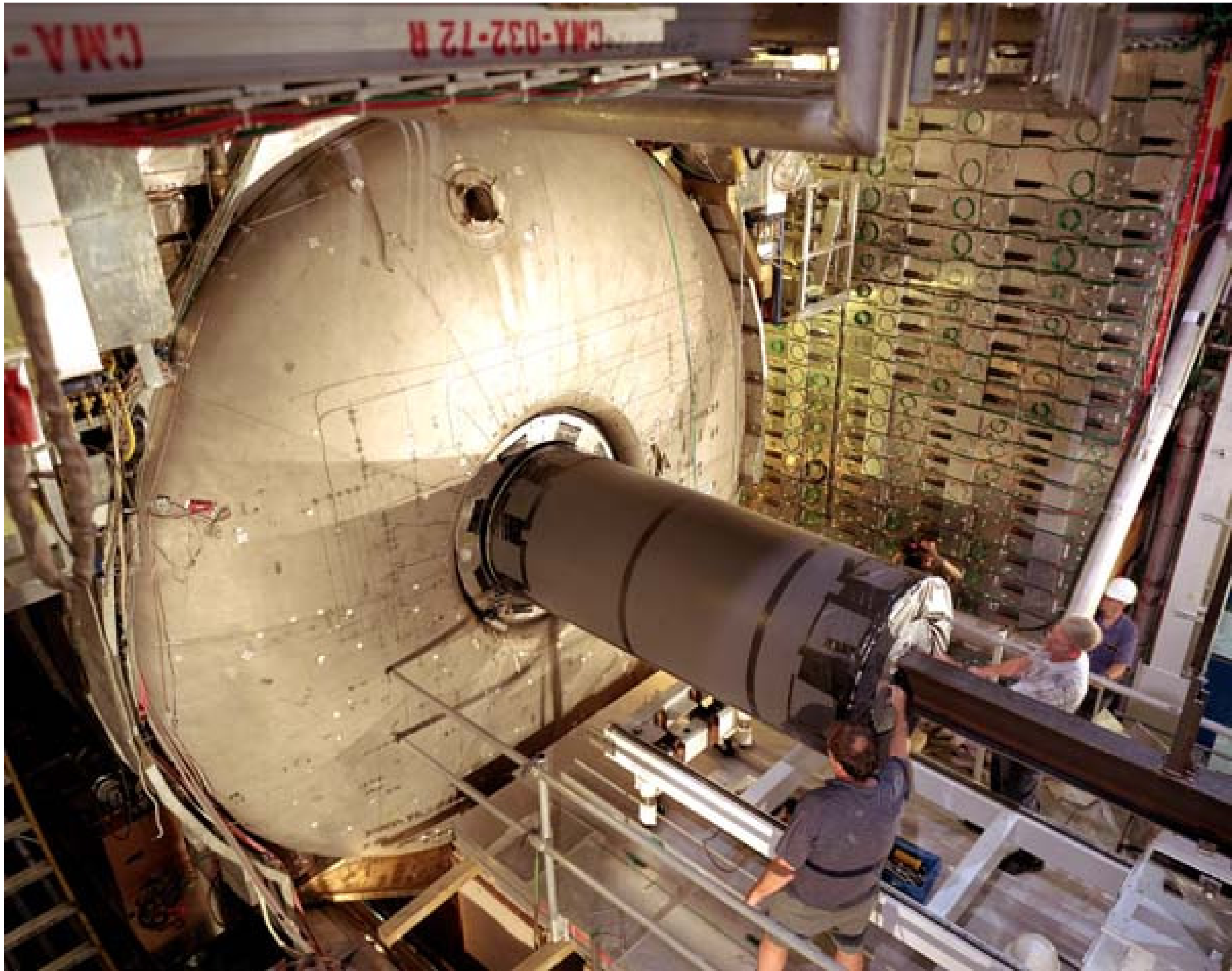




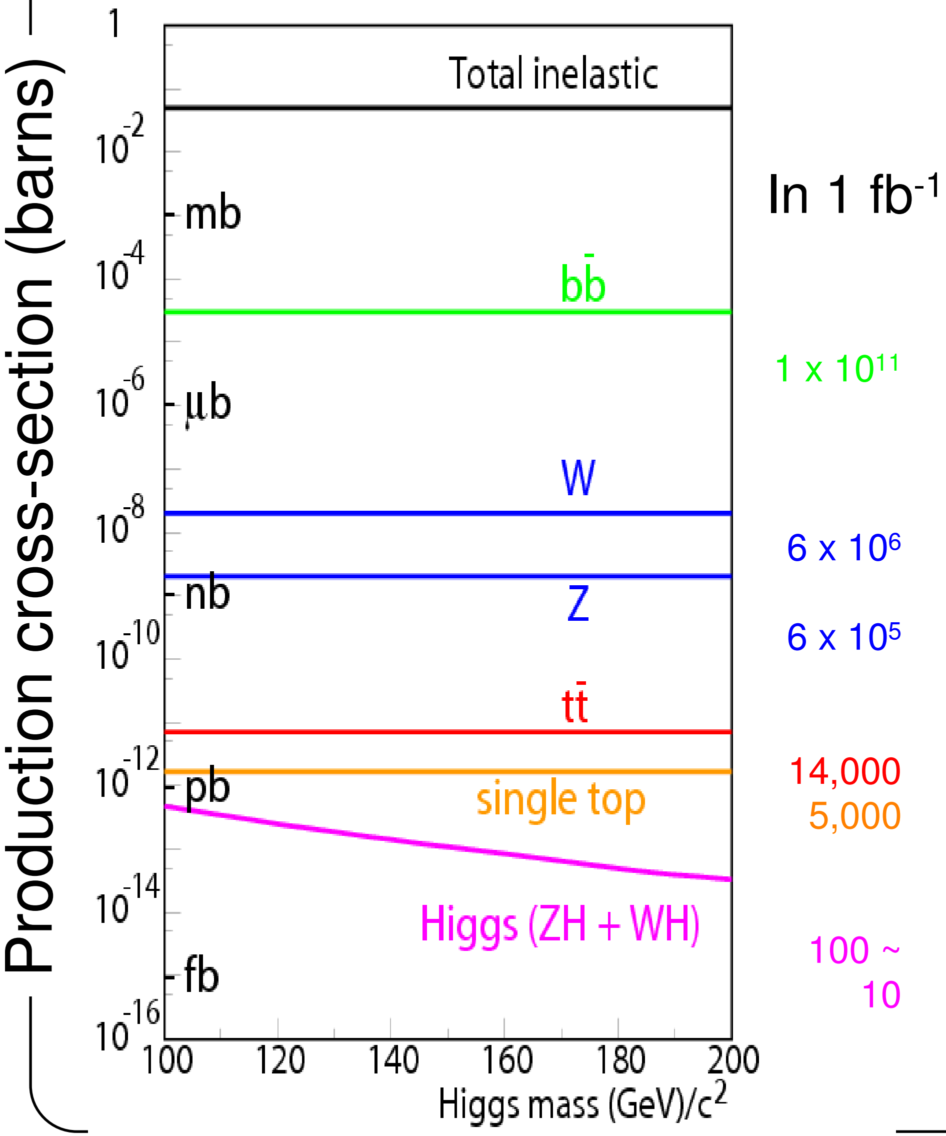
Experiments: CDF



Experiments: D0



Tevatron Collisions I



Two main areas

- B Physics
- "High" Pt Physics
  - SM (QCD)
  - SM(EWK)
  - SM(Top)
  - Higgs, BSM

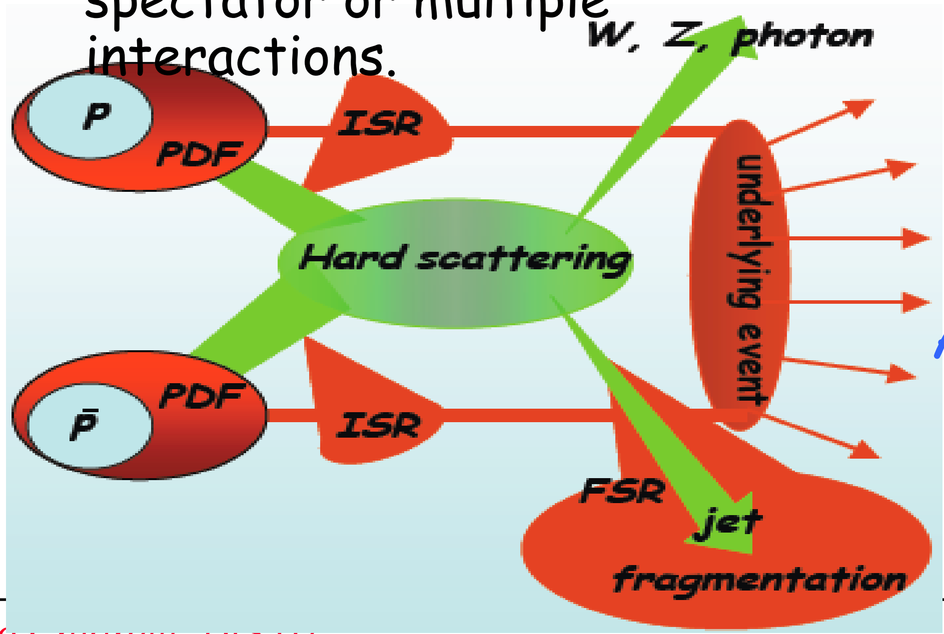
- Trigger and analyses being retuned to match the challenge
- As luminosity increases experiments are forced to deal with new challenges

At stake the capability to go down the ladder and explore the fb region

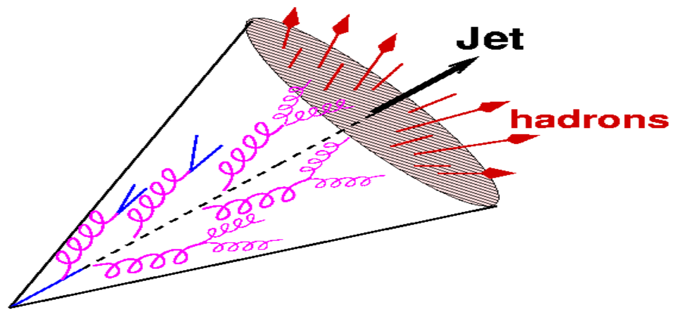
Tevatron Collisions II

The hard scattering is not all there is!

- ☞ Parton Distribution Functions (PDF): fraction of (anti)proton carried by incoming partons.
- ☞ Underlying Event (UE): extra stuff produce by spectator or multiple interactions.



- ☞ Initial and Final State Radiation (ISR, FSR): extra gluons radiating off the original/final partons.
- ☞ Jets: fragmentation of quark/gluons and recombination into hadrons reconstructed inside a cone.



All of these processes, and more, have an impact on what we measure

Some CDF results for Win 07

QCD

- b-bbar dijet production cross section (260 pb^{-1})
- Z+jets cross section measurement (1.1 fb^{-1})
- $Z \rightarrow$ b-bbar
- Dijet production cross section measurement (1.13 fb^{-1})

B Physics

- Lifetime measurements:
  - B+, B0, Bs and Λ_B (1fb^{-1})
- Rare decay searches:
  - $B^+ \rightarrow \mu^+\mu^- K+$, $B^0 \rightarrow \mu^+\mu^- K^*$, $B_s \rightarrow \mu^+\mu^- \phi$ (1fb^{-1})
  - $B \rightarrow hh$

EWK

- Observation of WZ production
- Evidence for ZZ production
- W mass, width

Top

- Top mass in all-jets channel
- Production cross section (lepton+isolated track)
- Search for W' using the single top sample
- Top Production Mechanism (gg vs qq)
- Top Charge

New Phenomena

- Search for New Particles Coupling to Z+jets (b'->Z+b) in 1.1 fb^{-1}
- SUSY trilepton combined limit - 0.7 to 1 fb^{-1}
- High-mass dielectron (Z' search) - 1.3 fb^{-1}

Higgs (fb^{-1})

- $H \rightarrow \tau\tau$ SUSY Higgs
- $H \rightarrow WW$ ME-based analysis
- $ZH \rightarrow llbb$ 2D-NN and MET fitter analysis

Some results from D0

After ICHEP

- B physics:
  - LB lifetime in 1.3 fb^{-1}
  - Search for Bs oscillations in 1.2 fb^{-1}
- QCD
- EWK
  - Wg in 900 pb^{-1}
- Top
  - σ(ttbar)
- Searches
  - GMSB SUSY
  - Fermiophobic Higgs
  - ZH

Winter 07

- B Physics
  - $B_s \rightarrow \mu\mu$ 2 fb^{-1}
- QCD
  - Triple jet differential cross section 1.1 fb^{-1}
- EWK
  - $Z\gamma^* \rightarrow 4l$ 1 fb^{-1}
- Top
  - σ(ttbar)
    - → Dilepton
    - → L+jets
  - Top mass
  - Single top
- Searches
  - 2^{nd} generation LQ
  - WH (many channels)
  - Updated SM Higgs limit
  - $H \rightarrow \tau\tau$

B Physics at an Hadron Collider

Thought to be almost impossible

- ☞ Exploits large cross section
  - ⇨ Need tight selection at trigger level
  - ⇨ Tracking capability at L1 and displaced track trigger at L2 at CDF

  Challenge at high luminosity
- ☞ Some very recent results:
  - ⇨ Bs oscillations [Observed by CDF with $1fb^{-1}$]
  - ⇨ $B \rightarrow hh$ [$1fb^{-1}$]
    - → A_{CP} in $B^0 \rightarrow K\pi$, $B^0_s \rightarrow K\pi$
    - → BF: $B \rightarrow KK$, $B \rightarrow \pi K$, $B \rightarrow \Lambda p$
  - ⇨ Search for rare B decays [D0 with 2 fb^{-1}]
    - → $Bs \rightarrow \mu\mu$, $B_d \rightarrow \mu\mu$
  - ⇨ Measurement of B_c mass, new B Baryons states, excited states

Talks by M.Corcoran, M.Heck, B.Kehoe, B.Reisert

Bs oscillations

D0 has a limit (900 pb^{-1})

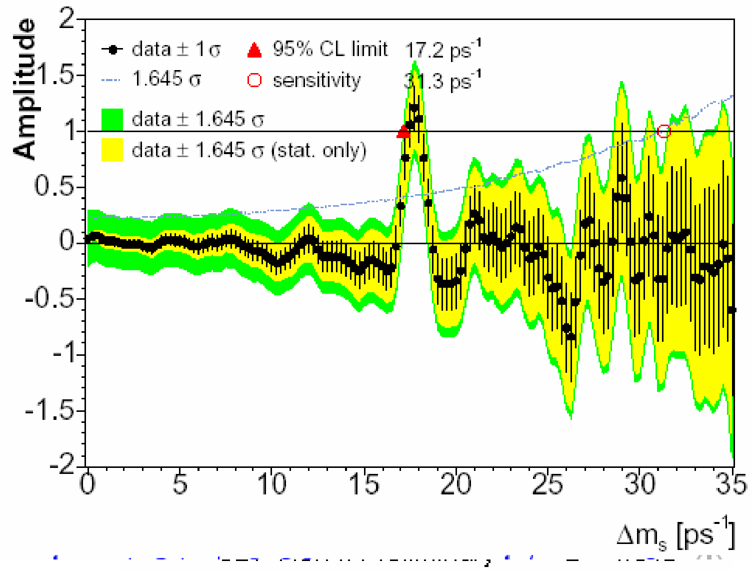
- ☞ $14.9 < \Delta m_s < 21\ ps^{-1}$ (90% CL)

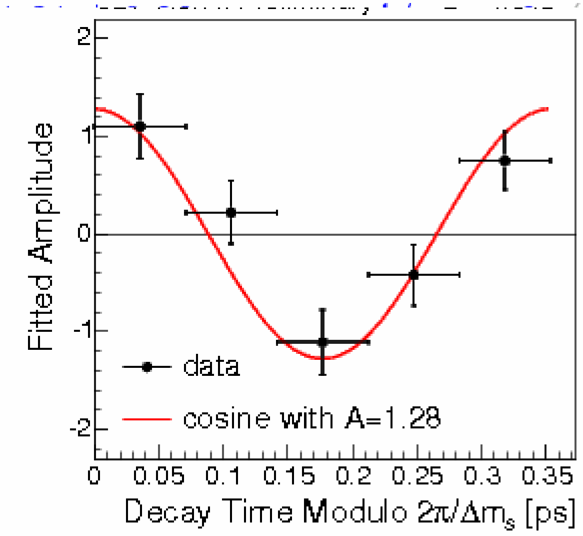
CDF, with 1fb^{-1} presents

- ☞ Observation of B_s Oscillations

PRL 97, 242003 2006

- ☞ $\Delta m_s = 17.77 \pm 0.10(stat) \pm 0.07 (syst)\ ps^{-1}$: > 5σ observation
- ☞ Same data set used for previous (spring 06) limit
  - ⇨ Improved selection
  - ⇨ Improved analysis technique
  - ⇨ A lot of efforts



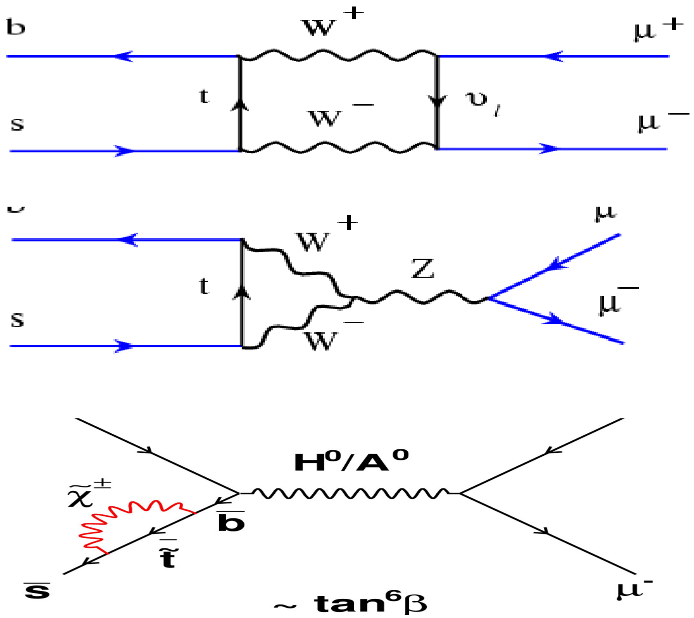


Talk by Bob Kehoe

Rare decays as window to new physics

Some decays are predicted with BF 10^{-9} in the SM but have a potentially much larger rates in SUSY models

$$BR(SUSY) \propto BR(SM) \cdot \frac{m_b^4 \cdot (\tan\beta)^6}{m_{H^0}^4}$$



D0 new result with 2 fb^{-1}

- 3 events (2.3+-0.7 exp.)
- <9.3(7.5)10^{-8}@95(90)% CL

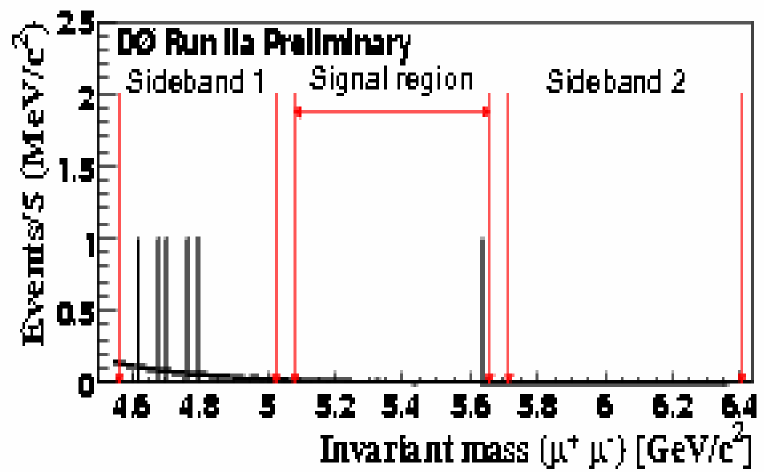
Not yet combined with CDF 0.8 fb-1 CL limits:

⇨ B_s<10(8) 10^{-8} 95(90) %

⇨ B_d<2.3(2) 10^{-8} 95(90) %

→ To be updated soon..

Run IIa data taking (1.3 pb^{-1})
1 evts, 10.8±0.2 exp

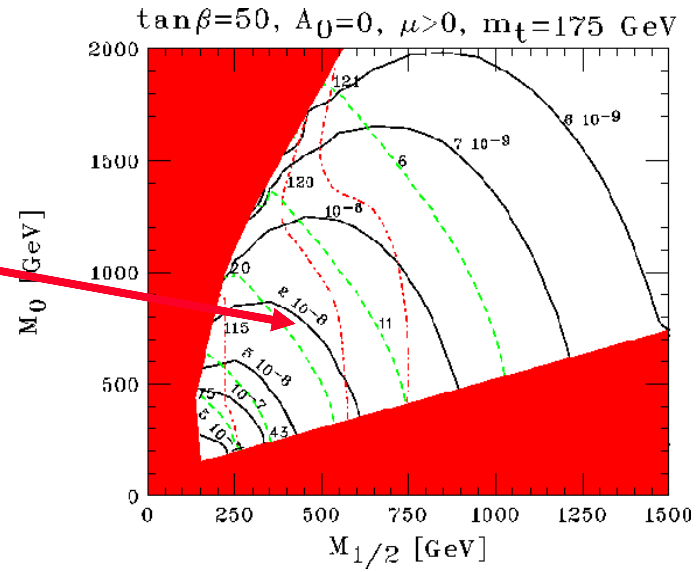


Giorgio Chiarelli, DIS 07

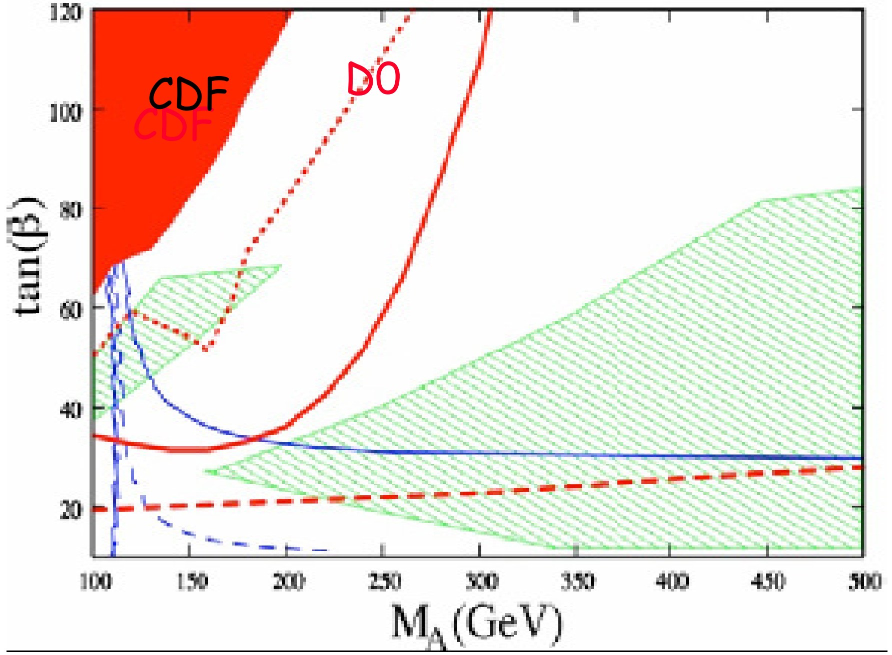
SUSY limits-examples

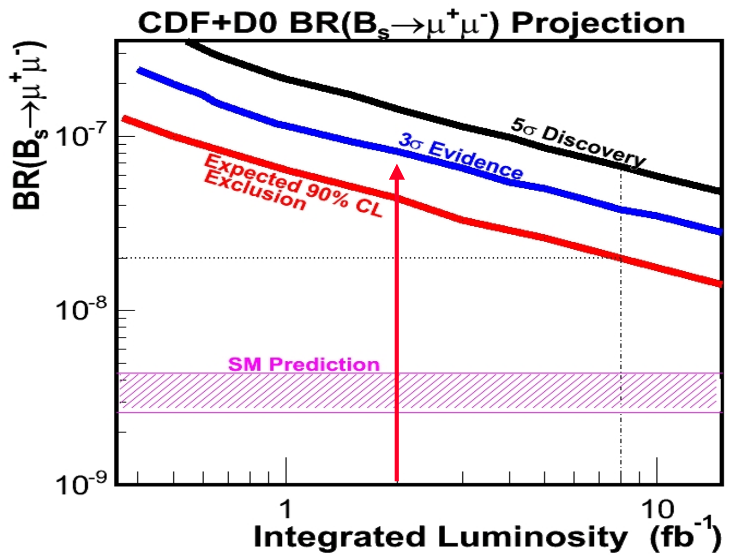
B_d 2.3(2) 10^{-8}@95(90)%CL,

B_s<9.3(7.5) 10^{-8} @95 (90)% CL



M.C., Menon, Wagner





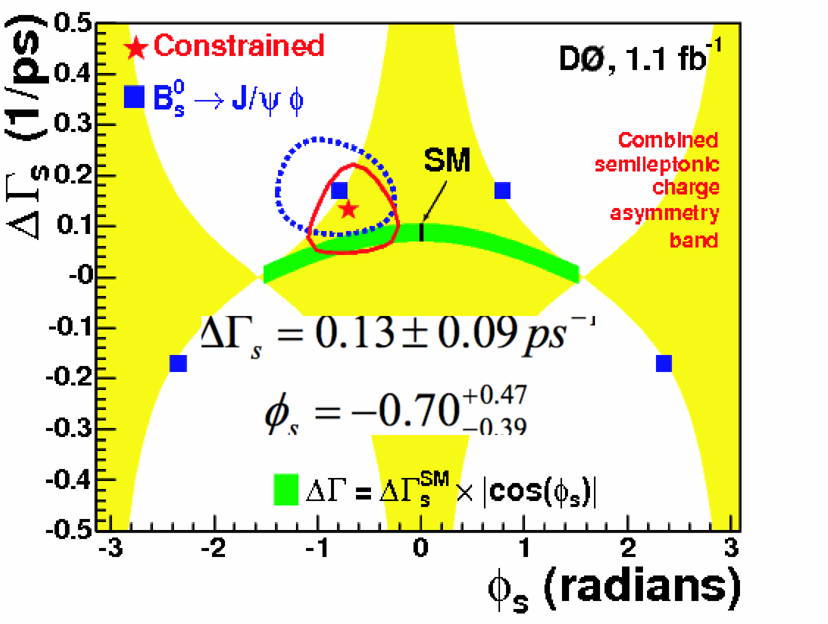
M. Carena (Moriond 2007)

See M. Corcoran

Lifetimes, masses…new states

D0

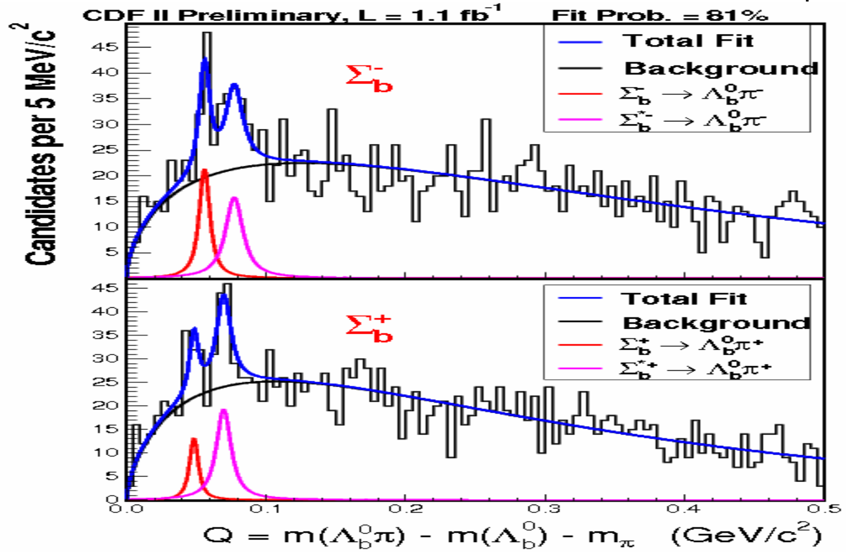
- single measurement of τ_{Bs} using s.l. decays
  - Combination of some measurements of its own with the Δm_s from CDF and measurements from B factories



See Bob Kehoe, Martin Heck, M. Corcoran

Study of B states:

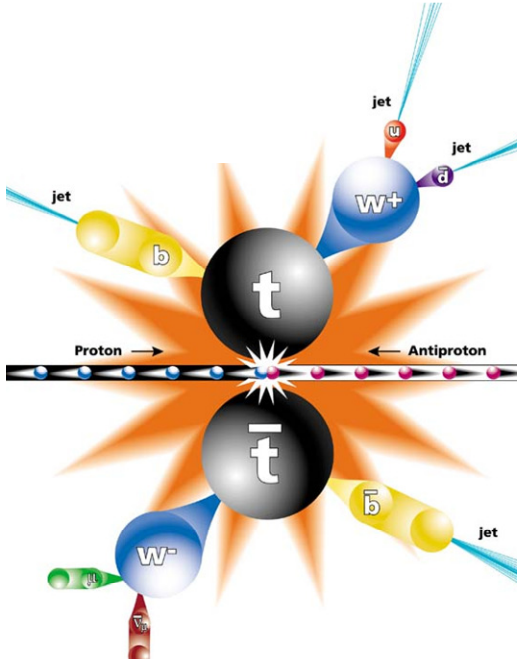
- B_c mass and properties
- New measurement of Λ_B lifetime (1 fb^{-1})
  - D0:
    - → 1.28±.11±.09 ps (sl)
    - → 1.3 ±.14±.05 ps (exc)
  - CDF
    - → 1.5±0.77±0.012 ps
- CDF: Observation of Σ_B and Σ_{B^*}



High P_T Physics

Need to define a clear set of physics objects

- ☞ Jets
- ☞ High pt charged lepton
- ☞ neutrinos
- ☞ B tagged jets
  - ⇨ Displaced tracks
  - ⇨ Soft lepton id



High mass objects (top, Higgs, New particles) decays into jets, leptons (charged and neutral)

- ☞ Challenge: reconstruct initial parton state

QCD Physics

Basics for any possible analysis:

- ☞ Jets carry information about QCD, PDF, couplings
  - ⇨ Et and angular distributions, fragmentation
  - ⇨ Comparison to pQCD predictions
- ☞ Measuring jets means understand calorimetry and tracking
- ☞ Can be tools (or background) in many physics topics

Results:

- ☞ Inclusive jet cross section (inherited *discrepancy* with pQCD from Run I)
- ☞ Jet fragmentation
- ☞ Dijet mass x-section
- ☞ W+jets, Z+jets production
- ☞ Underlying events
- ☞ Diffraction

See talks by

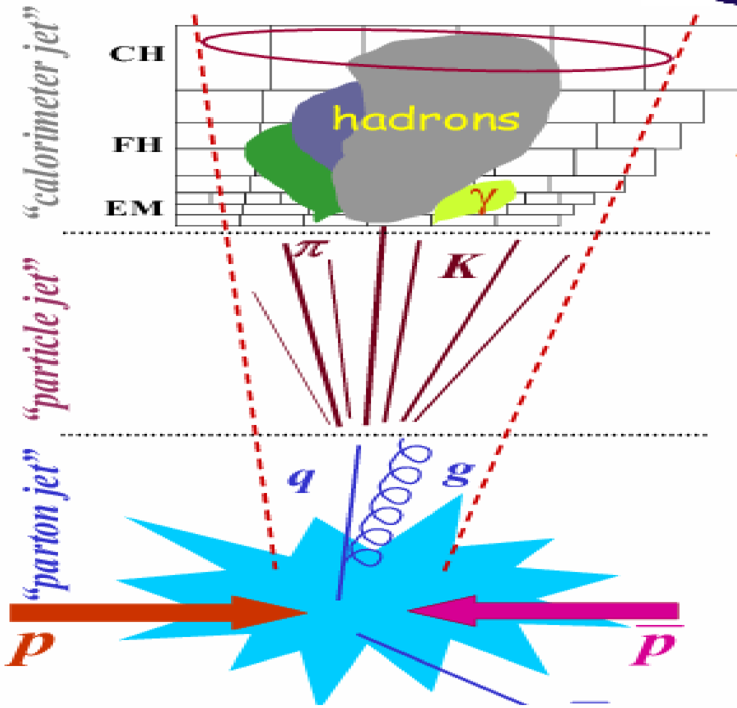
O. Atramentov, J. Cammin, M. D'Onofrio, L. Pinera, C. Mesropian, S. Vallecorsa

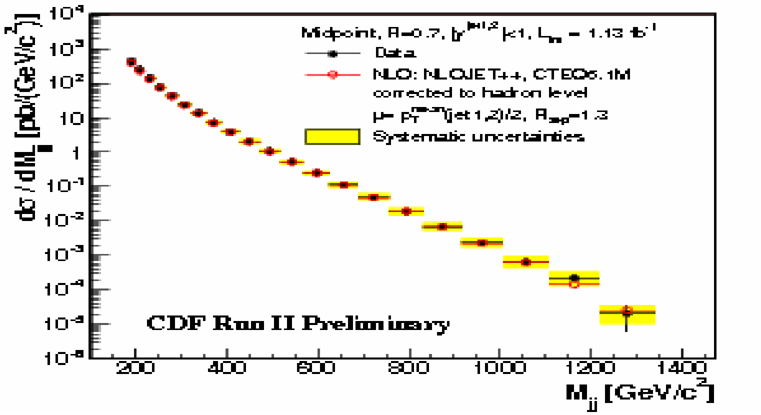
Inclusive jet Physics

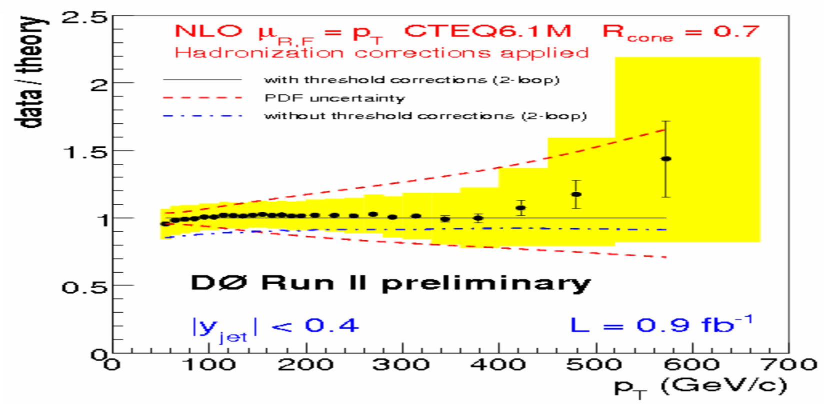
Jets are a key probe

- ☞ Fundamental in measuring top mass, search for new physics, test of the SM..
- ☞ Can show early appearance of new physics!

Large effort by both experiments in understanding production and properties



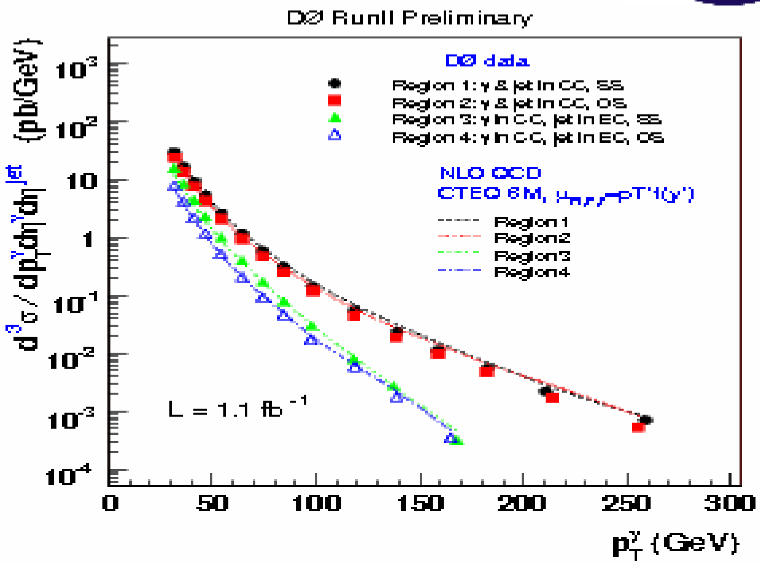


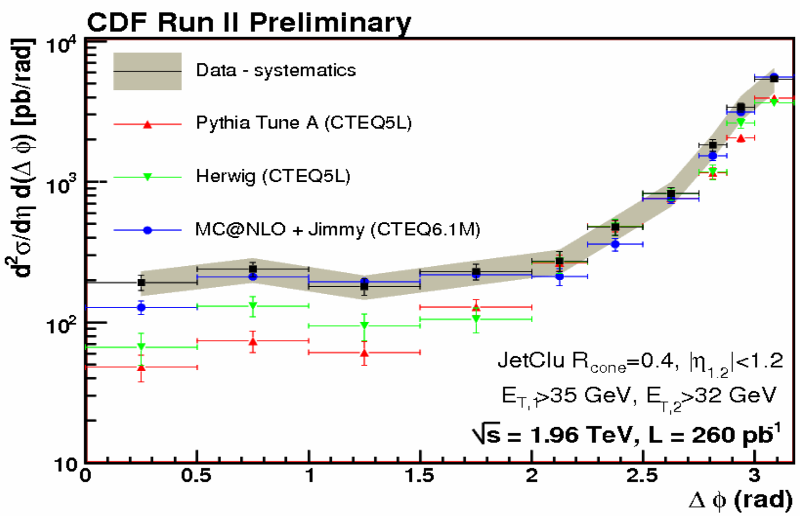


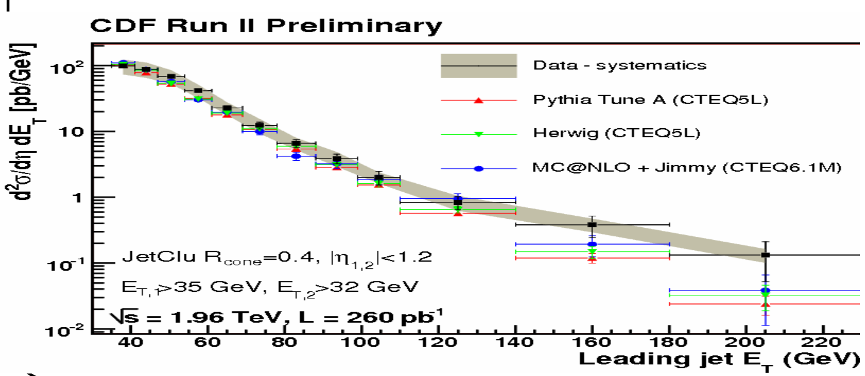
Less inclusive states

With larger statistics and improved detectors more and more results from prompt photons:

- D0 measures the triple γ–jet differential cross sections in 1 fb^{-1}
- CDF exploits smaller data sample collected with trigger devoted to detect secondary vertices and studies bbar







EWK Tests of the SM

Basics for top, searches

- Decay, associated production
- Often background for rare processes
- Discrepancy from SM would signal new physics

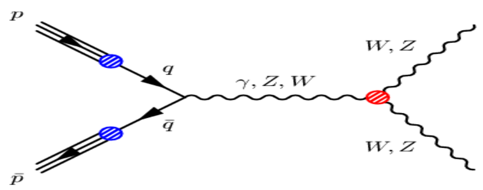
Both CDF and D0 measure

- Inclusive and differential production cross section (PDFs..)
- Multiboson production (WW, ZZ, WZ, Wγ, Zγ: really at the boundaries of the Tevatron reach
  - WZ:
    - First observation by D0 (3.3 σ)
    - CDF WZ at 6 σ
  - WW production observed with 0.35 fb^{-1}
    - CDF, D0
  - CDF evidence for ZZ at 3 σ (winter 07)
  - Zγ, Wγ test of trilinear gauge coupling
    - Zγ measured by CDF (0.35 fb^{-1}) and D0 (1 fb^{-1})
    - Wγ: D0 measures an angular distribution looking for the radiation amplitude zero.
- CDF measures W mass and width

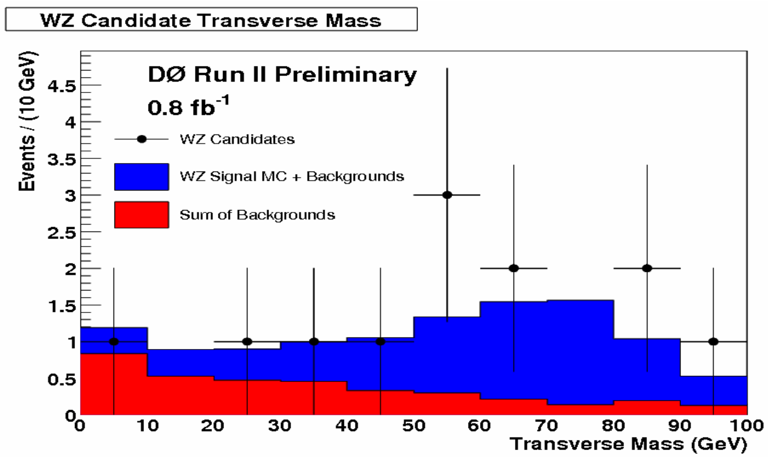
See talks by S.Malik, Y.Maravin, A.Robson

ZZ, WZ

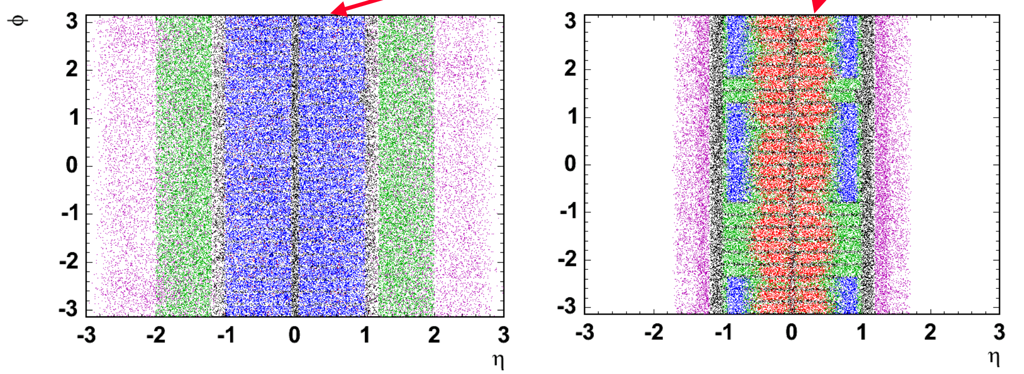
Intermediate steps towards *WH*,
$WZ \rightarrow lll\nu$ has a NLO
σ=3.7±0.1 pb



- D0 presented a 3.3 σ evidence in Summer 06
- $\sigma = 3.98^{+1.91}_{-1.53}$ (stat+sys)pb



- Winter 07: CDF improved its analysis by extending acceptance for e and μ



Source	Expectation ± Stat ± Syst ± Lumi
Z+jets	1.22 ± 0.27 ± 0.28 ± -
ZZ	0.89 ± 0.01 ± 0.09 ± 0.05
$Z\gamma$	0.48 ± 0.06 ± 0.15 ± 0.03
$t\bar{t}$	0.12 ± 0.01 ± 0.01 ± 0.01
WZ	9.79 ± 0.03 ± 0.31 ± 0.59
Total Background	2.70 ± 0.28 ± 0.33 ± 0.09
Total Expected	12.50 ± 0.28 ± 0.46 ± 0.68
Observed	**16**

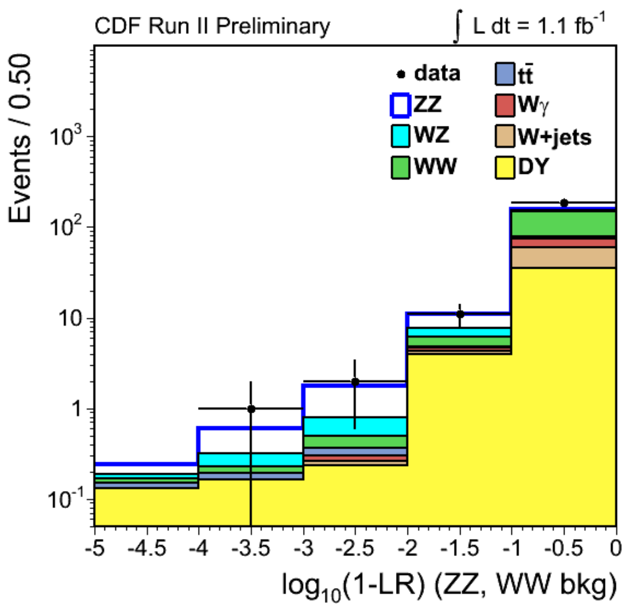
$\sigma(WZ) = 5.0^{+1.8}_{-1.6}$(stat.+syst.) pb

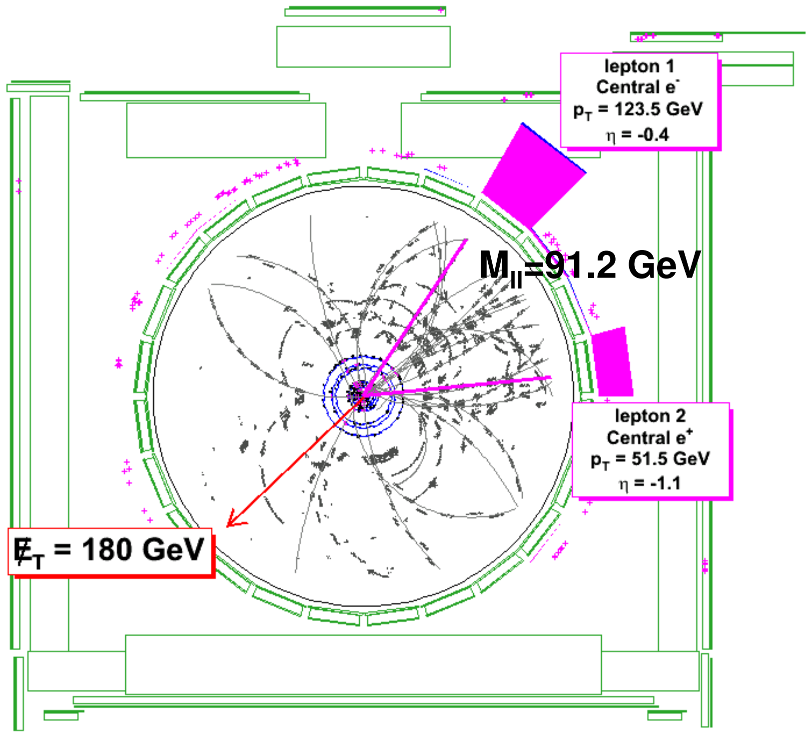
Prob(background only) < 1.5×10^{-7} (5.1σ)

ZZ

ZZ→4l is the smallest σ measured at the Tevatron: σ_{NLO}=2.1 pb

- CDF adds new channel (ZZ→llνν) to summer 06 analysis and, in 1.4 pb^{-1}, finds
  - ⇨ $\sigma=1.14^{+1.1}_{-0.8}$ (stat+syst) pb



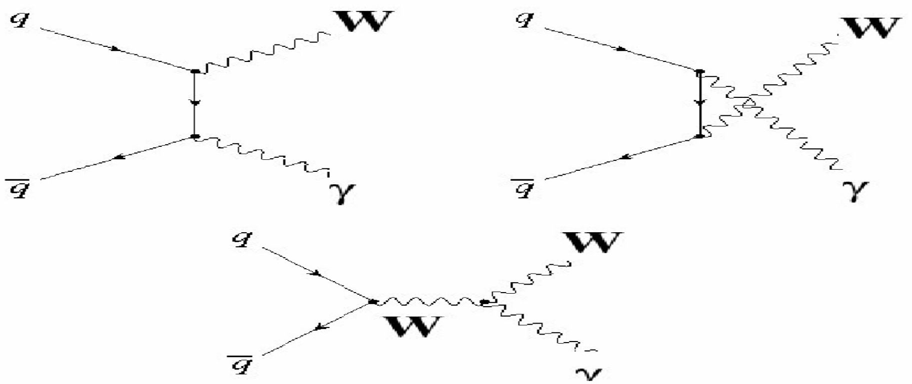


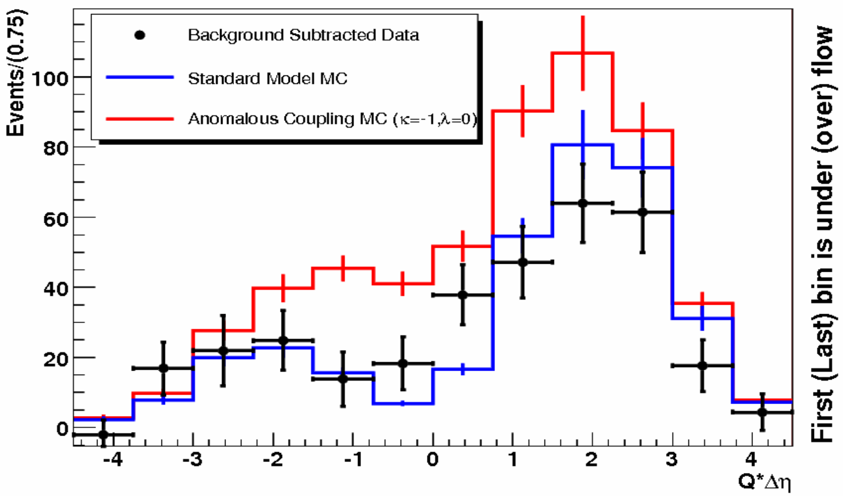
$Z\gamma$, $W\gamma$

The gauge structure of the SM has a crucial test in the (destructive) interference in $W\gamma$

- Both CDF and D0 measured $Z\gamma$ and $W\gamma$ cross section in 1 fb^{-1}
- CDF:
  - $\sigma(W+\gamma)$ = 19.1±2.8 pb
  - $\sigma(Z+\gamma)$ = 4.9±0.5 pb
- D0($E_T\gamma$>7GeV, M_T(lγ,MET)>90:
  - $\sigma(W+\gamma)$ = 3.2±0.5±0.2(lum)p
- $\sigma(Z+\gamma)$ =4.51±0.4±0.3(lum) pb

The interference among the three tree-level diagrams below create a zero in the $\cos\vartheta^*$ distribution at $\cos\vartheta^* = \pm 1/3$

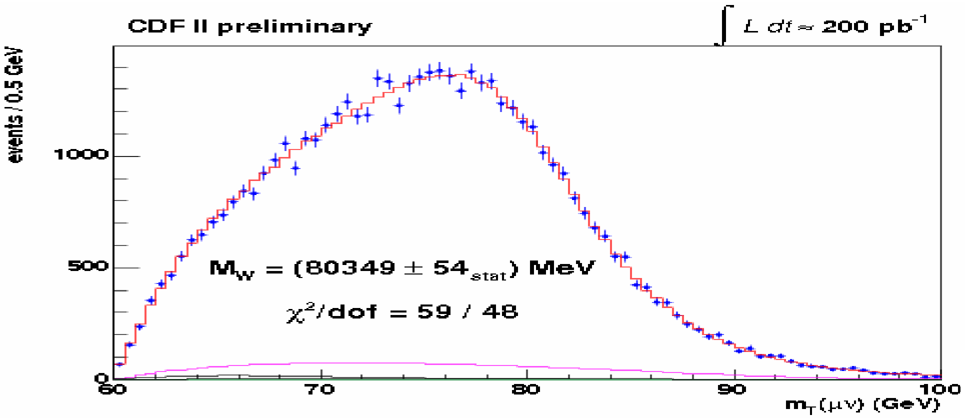


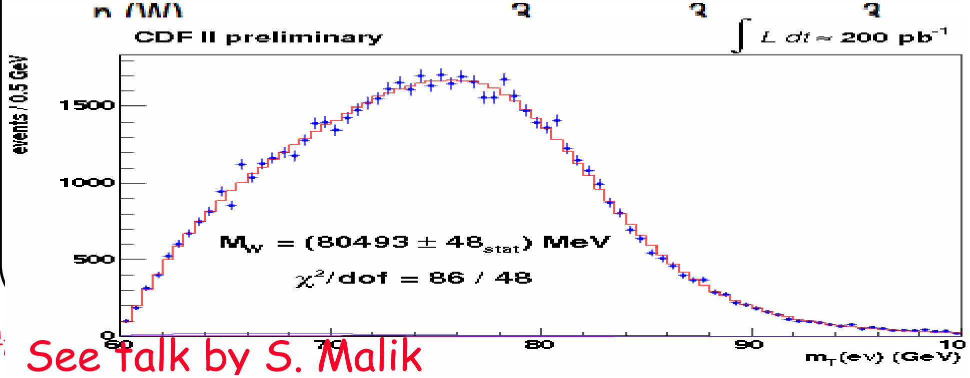


W mass and width

CDF presents the best single-experiment result, which is now statistically limited

MW = 80413±48 MeV/c²

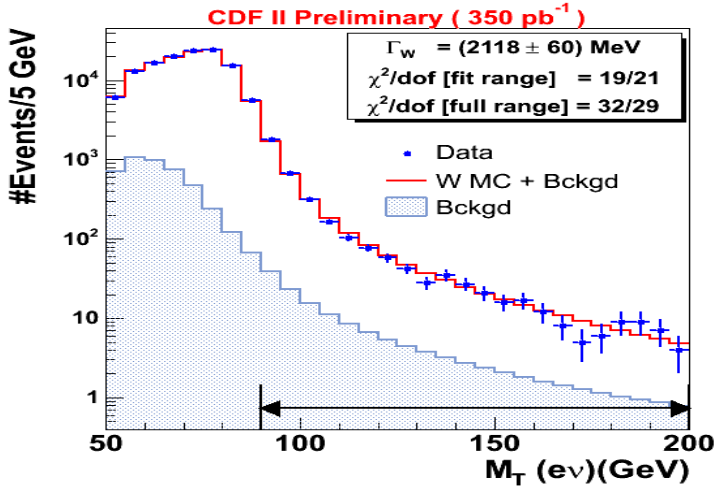


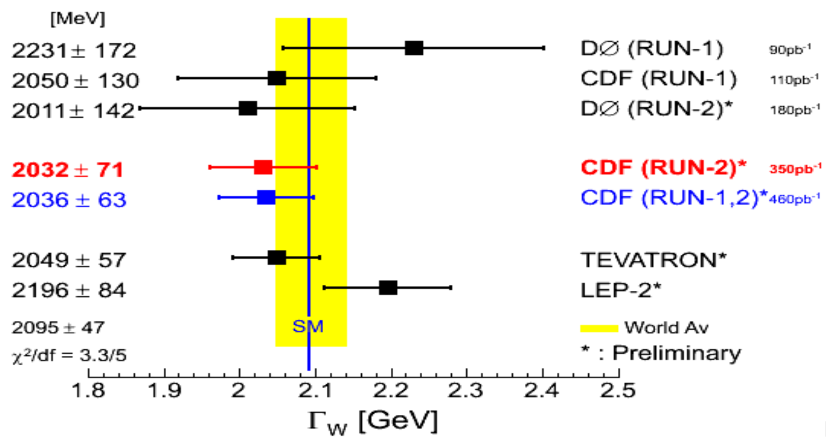


See talk by S. Malik

CDF also measure the W width

Γ_W = 2032±71 MeV/c²





Top Physics

Top has a strong relation with EWSB

- ⇨ Yukawa coupling ~1

Test SM and QCD prediction

- ⇨ Study of decay and production (Wtb vertex)

☞ Some studies performed in Run I

☞ With 1 fb^{-1} in Run II, performed precision measurements of:

- ⇨ ttbar production cross section
  - → Pre-requirement to select top-enriched samples
- ⇨ Top mass
  - → keeps improving

☞ Many ongoing analyses

- ⇨ Fundamental: go from evidence (D0 2007) to discovery of EW top production (single top)
  - → Direct measurement of Vtb
  - → Critical test of the SM
- ⇨ Helicity meaurement, top charge etc.

Talks by C.Gerber, S.Jabeen, J. Wagner

12 years of top

13 years ago (24/4) CDF "Evidence of top"

☞ February 1995 CDF and D0 "Top Discovery"

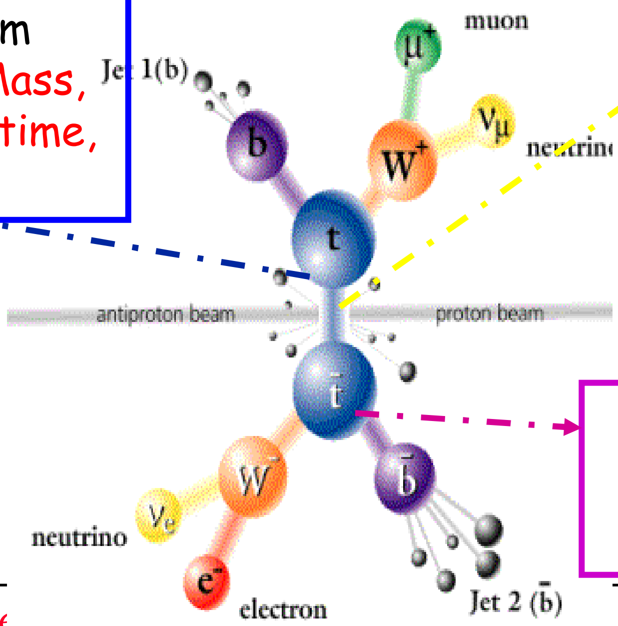
⇨ Run I studies with 110 pb^{-1}, Run II 1 fb^{-1}

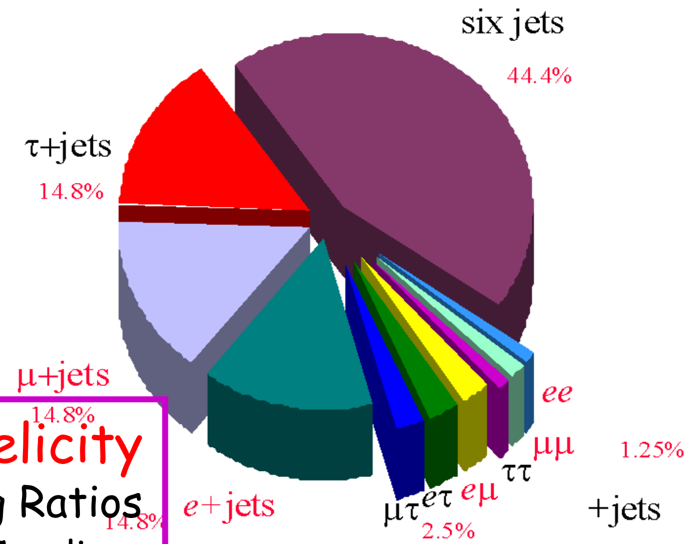
→ Top produced (mostly) in pairs…

→ Lots of decay channels to look at

Production cross-section
Production Kinematics

Top Quantum Numbers (Mass, Charge, Lifetime, Spin)

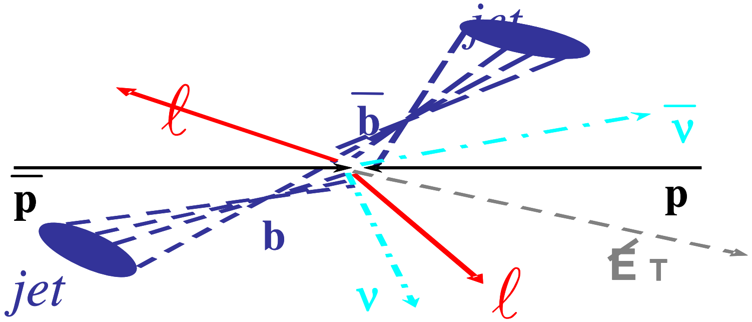




- W helicity
- Branching Ratios
- Anomalous Couplings

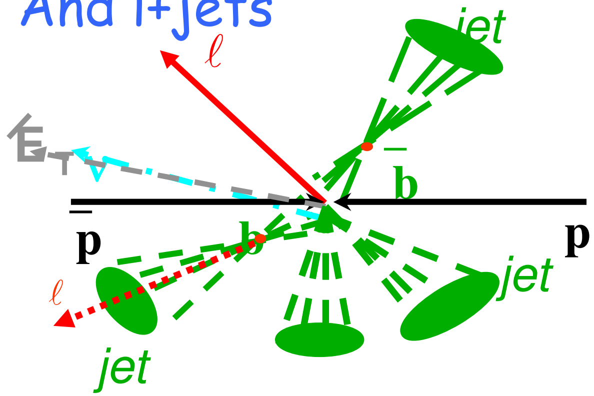
Top Production

Out of the different channels, select dilepton

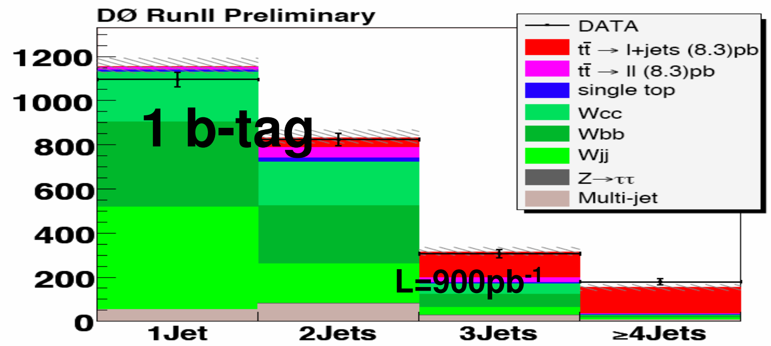


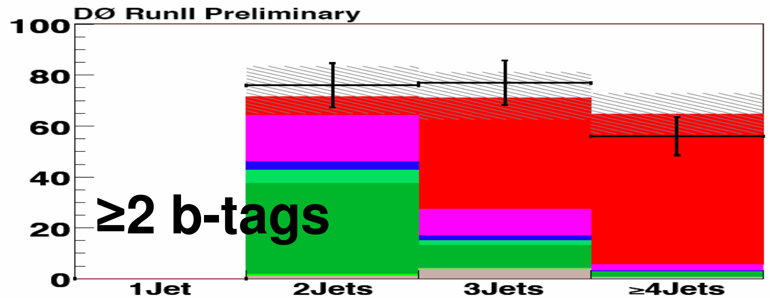
☞ to improve statistics use "identified lepton" + "isolated track"

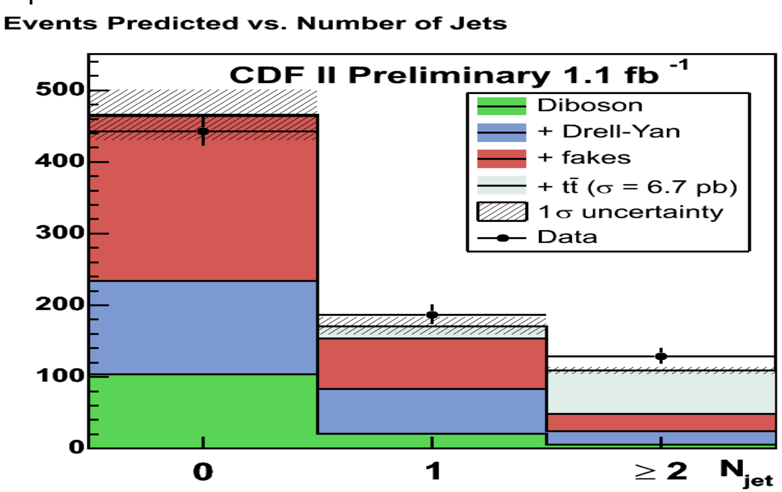
And l+jets



Use tagging to enrich sample
ε≈55% (bckg 0.5%)







Top cross section

Exp.& Th. Errors comparable:

- σ(all had): $8.3\pm1^{+2}_{-1.5}\pm0.5$ pb

σ_{tt}=6.8±0.6 pb (Kidonakis, Vogt)

σ_{tt}=6.7+0.7-0.9 pb (Cacciari et al.)

- Decay channel in dilepton more and more important, 1 fb^{-1}

D0: $\sigma_{tt}= 6.8^{+1.2}_{-1.1}(stat)^{+0.9}_{-0.8}(syst)\pm0.4(lumi)$pb

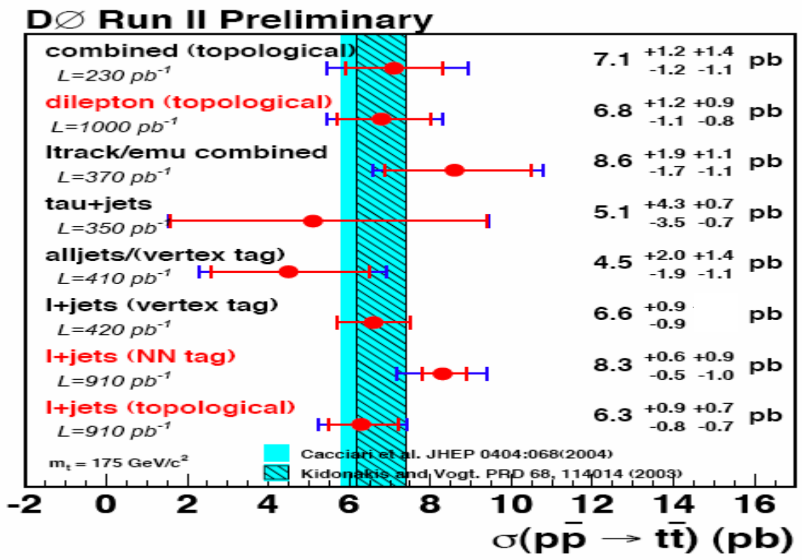
CDF σ_{tt}= 9.0±1.3(stat)± 0.5(sys)±0.5(lum)pb

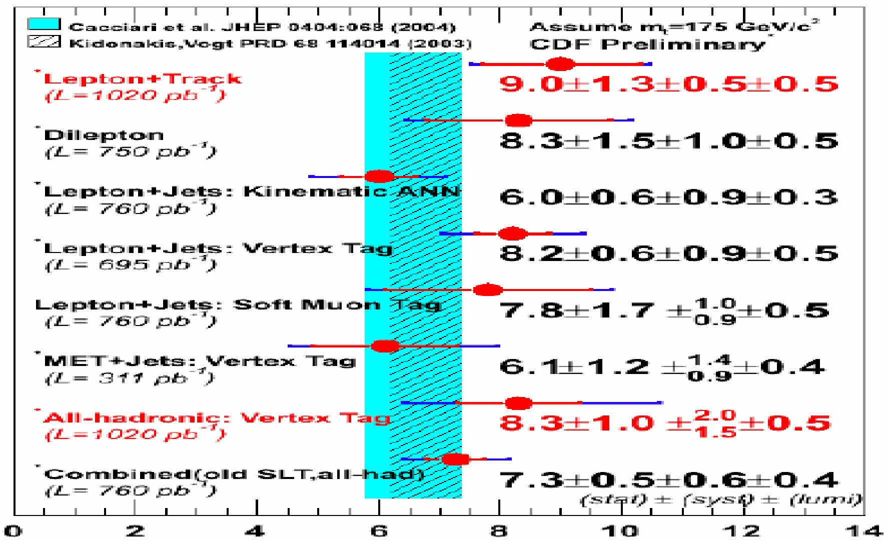
- D0 shows two results in l+jets with 1 fb^{-1}:

$\sigma_{tt} = 8.3\ ^{+0.6}_{-0.5}(stat)^{+0.9}_{-1.0}(syst) \pm 0.5\ (lumi)$ pb

Experimental accuracy reaching (in 2 fb^{-1}?) theoretical predictions

- More work ?
  - ⇨ Need NNLO calculation

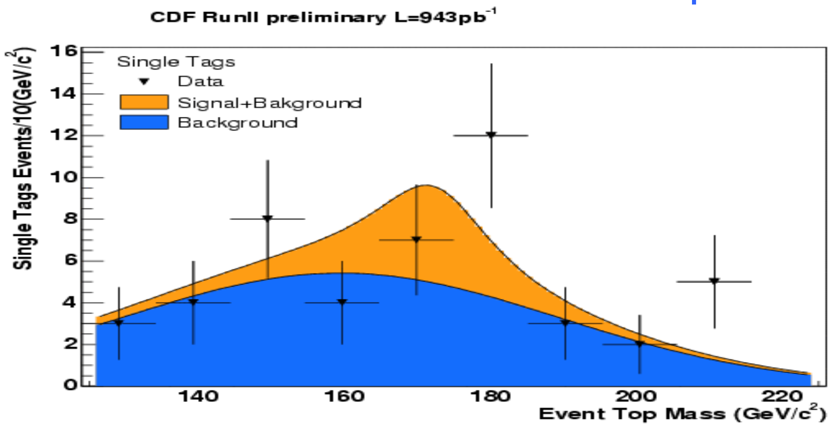


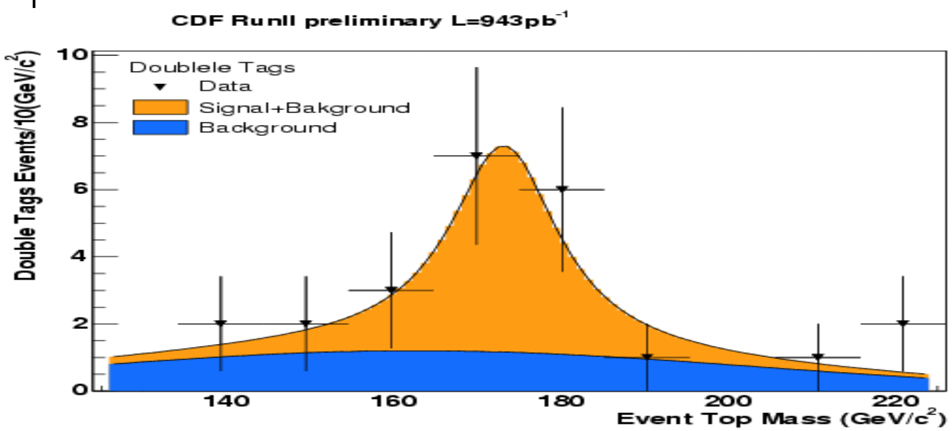


More on x-section and properties in Cecilia Gerber's talk

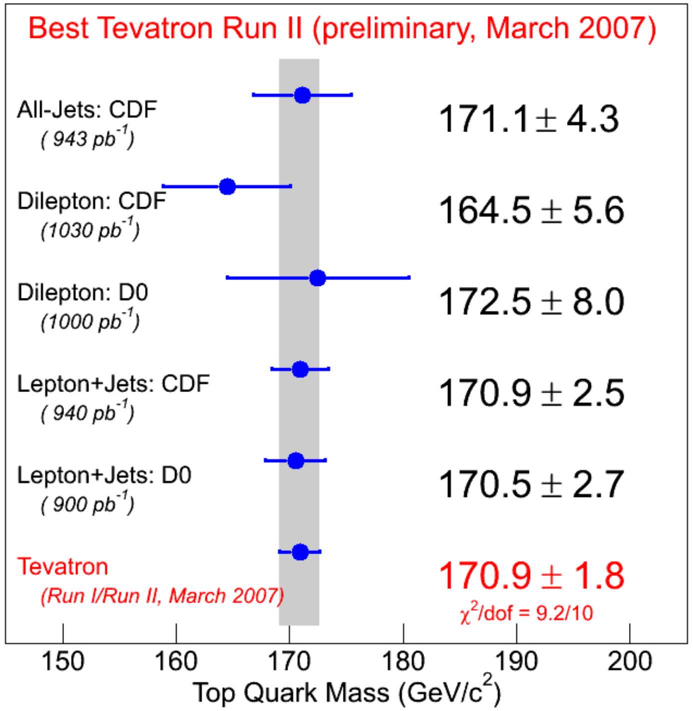
Top Mass, present and future

In each decay channel we also measure M_{top}





Great effort in understanding JES



New WA (March 07): Mtop= 170.9±1.8GeV/c^2

Top future (at the Tevatron)

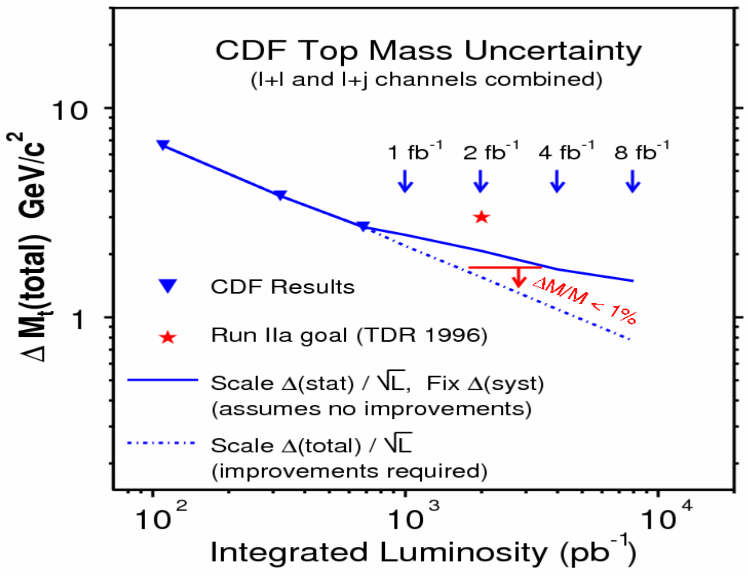
CDF and D0 can do well…

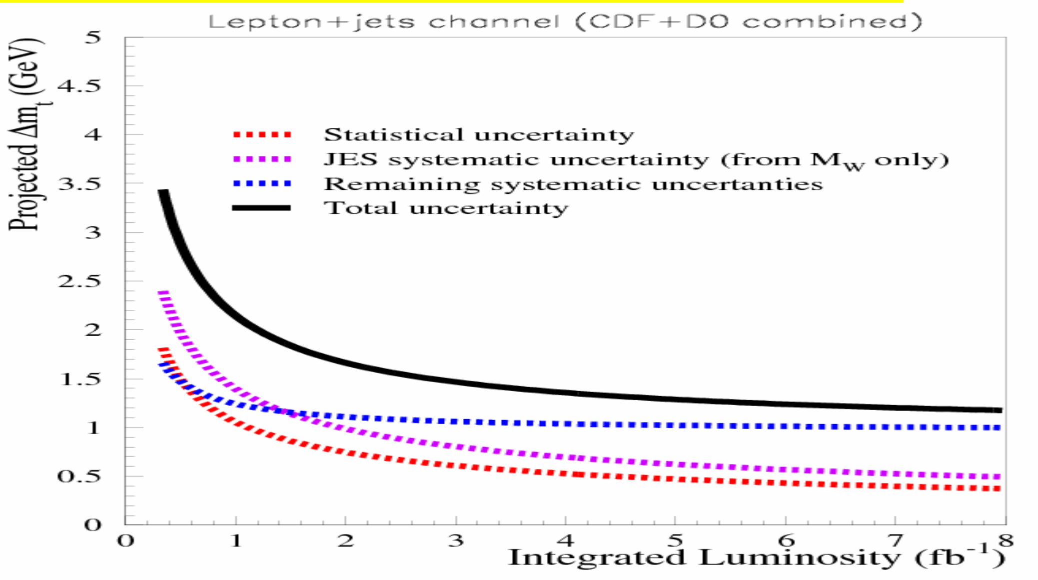
- Improved B tagger
- Z→bb calibration
- JES improves with the dataset

Together we can do even better…

- Possibility of better than 1% accuracy
  - ⇨ Tevatron legacy?

Already better than the TDR [3 GeV/c^2] (2fb^{-1})





Discussion on the meaning of a 1% accuracy (ongoing work with theoreticians)

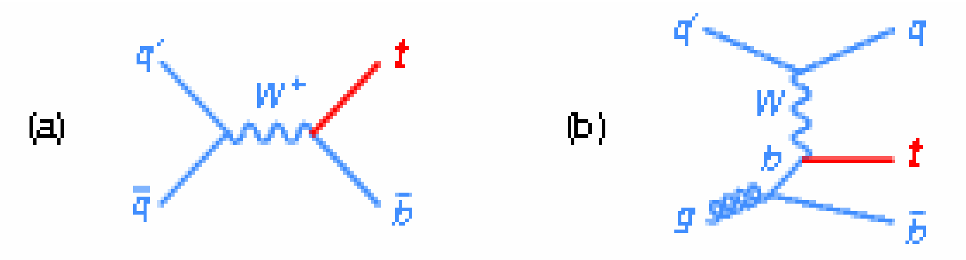
Single top

While top was detected in pairs, SM predicts that can be produced alone by EWK processes

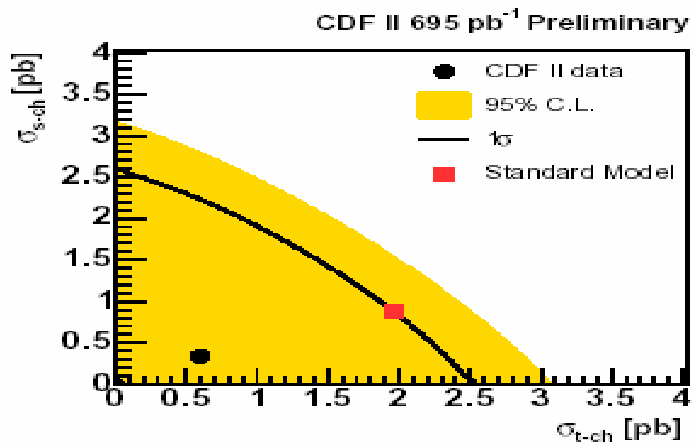
- Tiny production cross section in both channels:
  - ⇨ s-channel(a)=0.88 pb
  - ⇨ t-channel(b)=1.98 pb A.Robson,
- 1 fb^{-1} CDF set limit:
  - ⇨ $\sigma(s+t)<2.6$pb @95%CL

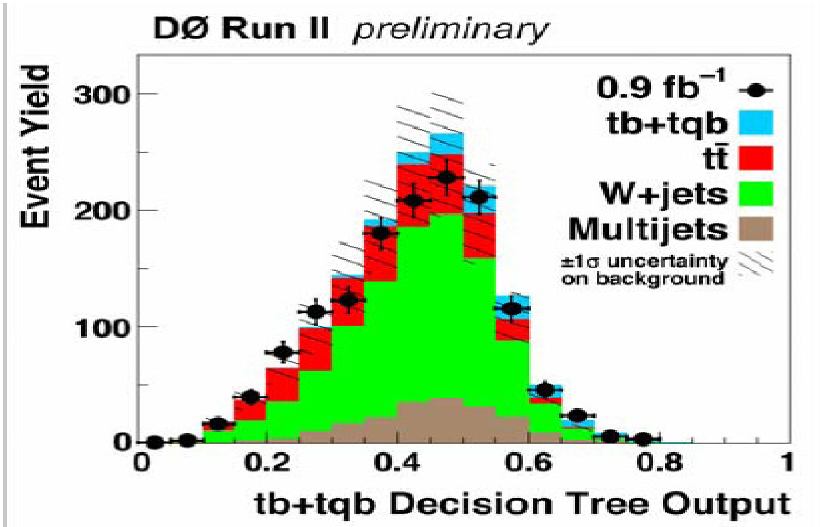
$\sigma \propto |Vtb|^2$

- Direct Vtb measurement



- D0 find a 3.4 σ signal in 0.9 fb^{-1}:



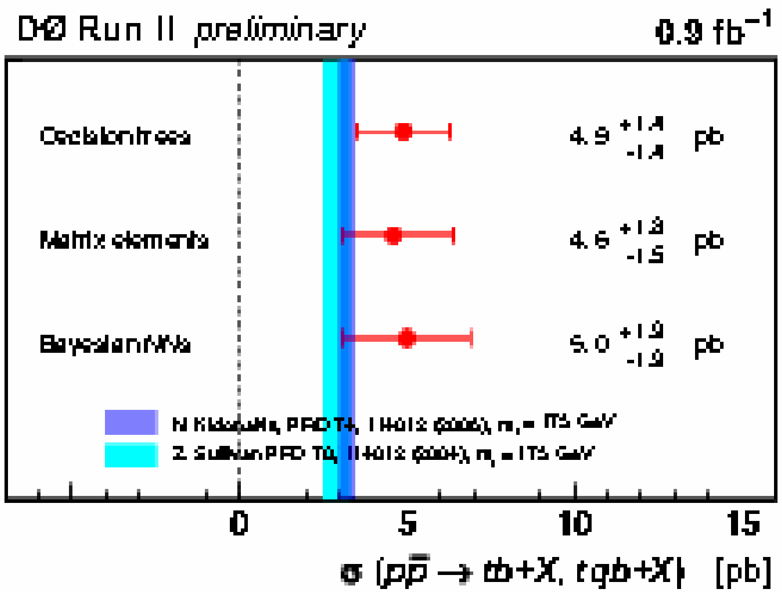


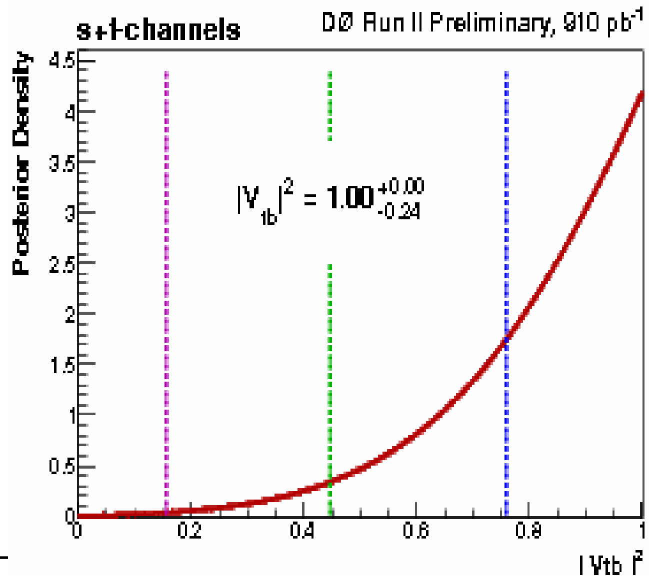
Talk by Shabnam Jabeen

Single top

D0 presented first evidence for single top this year

- Very challenging analysis
  - Several statistical methods used
    - One chosen (most powerful)
  - $\sigma(s+t)=4.9\pm1.4$pb
    - $0.68<|V_{tb}|<1$ @95%CL

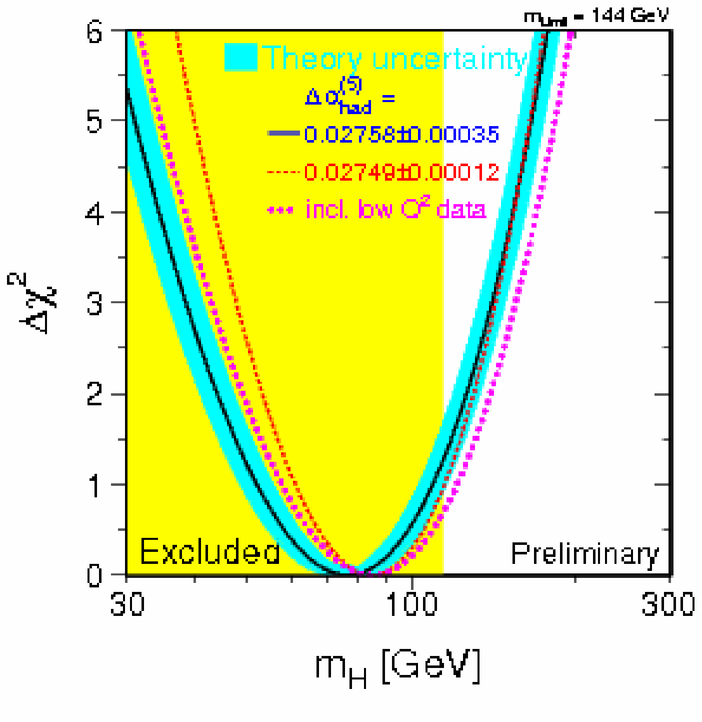




Indirect bounds for the Higgs

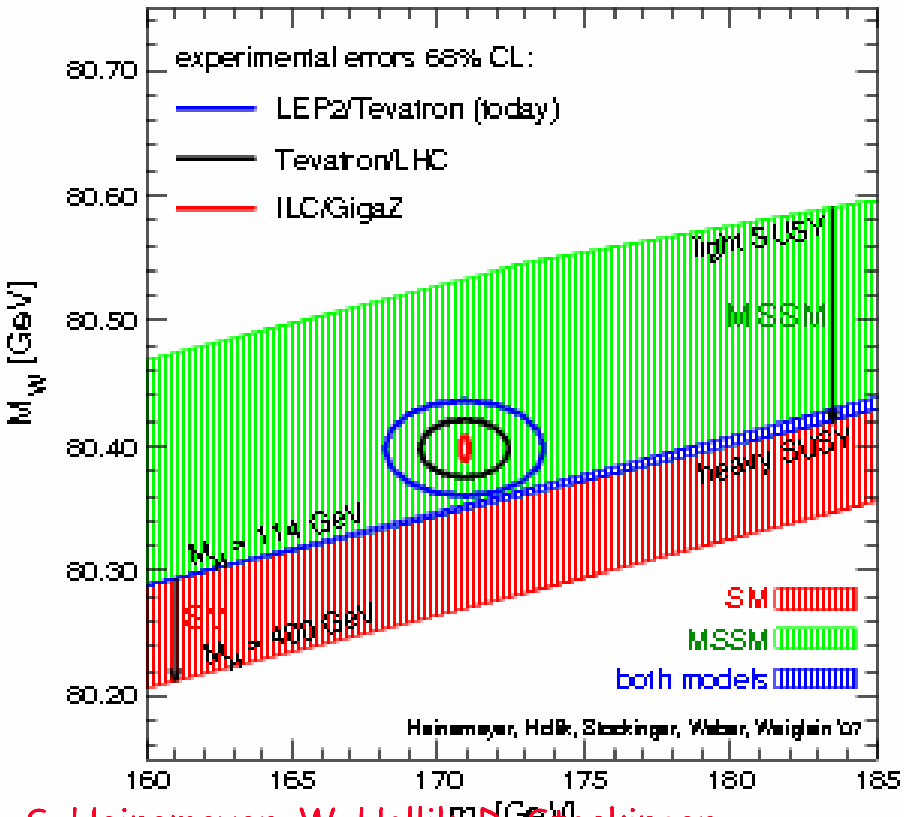
Tevatron is improving the understanding of the Higgs every day:

☞ M_H< 144 (182) GeV/c^2 @95% CL



TEWKG March 2007

Can bring us beyond the SM ?



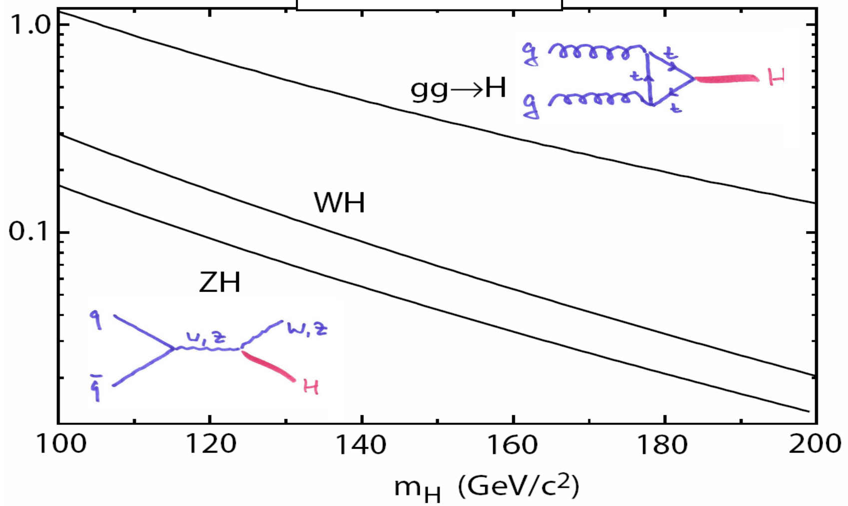
S. Heinemeyer, W. Hollik, D. Stockinger,

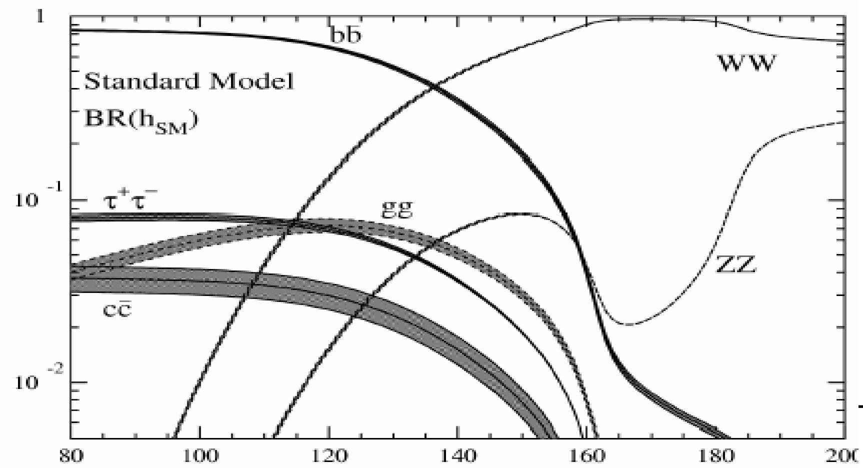
A.M. Weber and G. Weiglein, hep-ph/0604147

A direct path towards the Higgs

Light or heavy Higgs?

Production

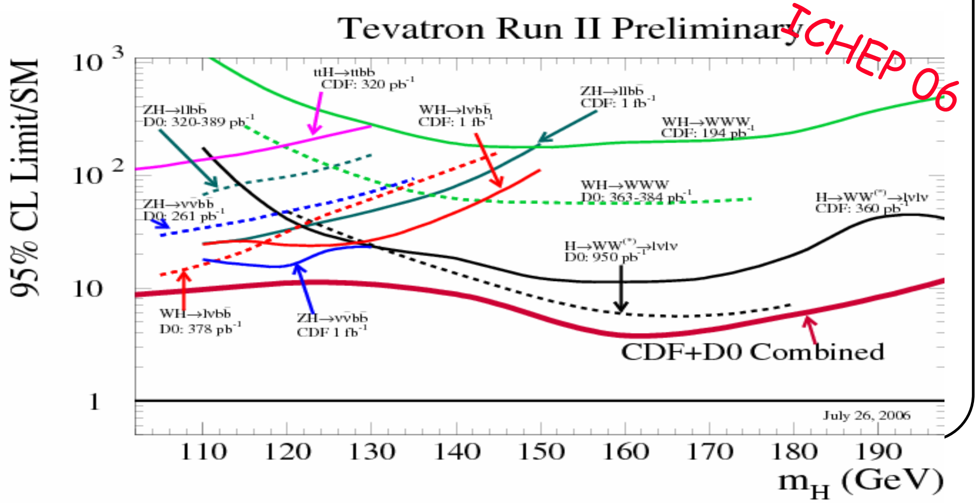




Strong b-tagging, large lepton coverage

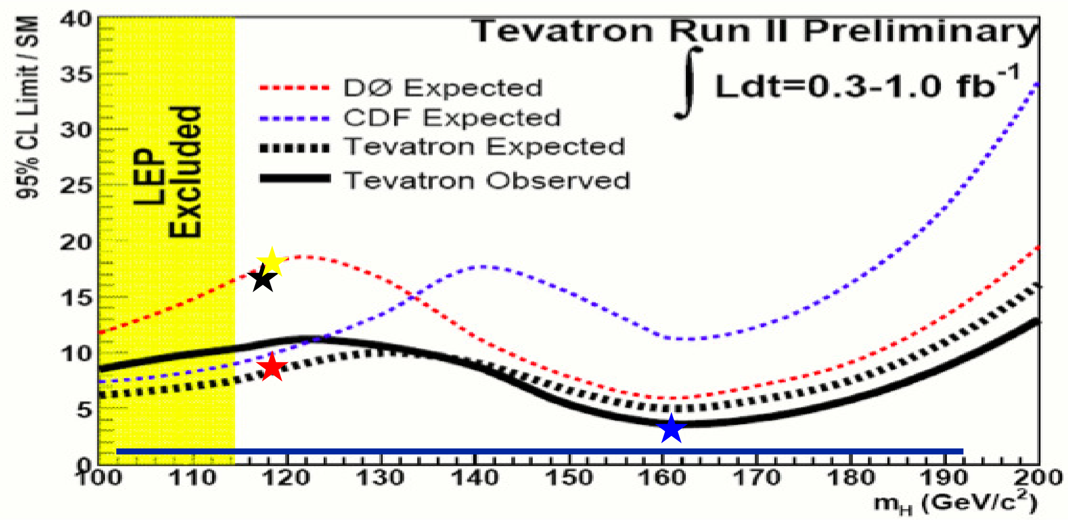
- X-section shows that we must use channels with large BF (no γγ)

m_H (GeV)	Limit/SM Exp.	Obs.
115	7.6	10.4
160	5.0	3.9
180	7.5	5.8

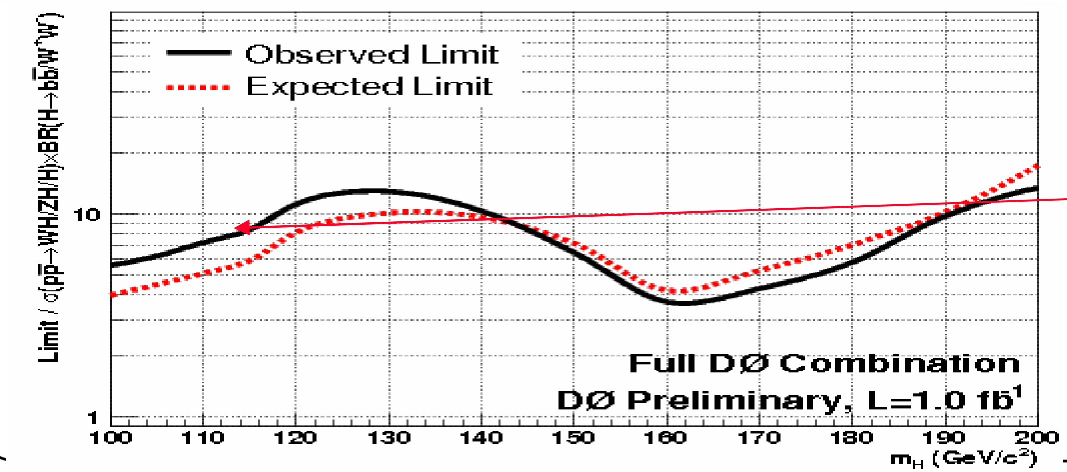


Ongoing effort

Last update in mid March (new CDF result on WW, ZH and from D0 on WH, ZH→new)



Analysis	CDF limit ($1fb^{-1}$) factor above SM observed (expected)	D0 limit ($1fb^{-1}$) factor above SM observed (expected)
ZH → νν bb @ 115 Technique: M_{jj}	16 (15)	~~40 (34)*~~
WH → lν bb @ 115 Technique: M_{jj} Technique: ME	26 (17)	★ 10 (9) ★ 13 (10)
ZH → llbb @ 115 Technique: NN2D	★ 16 (16)	33 (34)
H → WW → lνlν @ 160 Technique: ΔΦ (l,l) Technique: ME	9 (6) ★ 3.5 (5)	4 (5)



New, April 6 2007

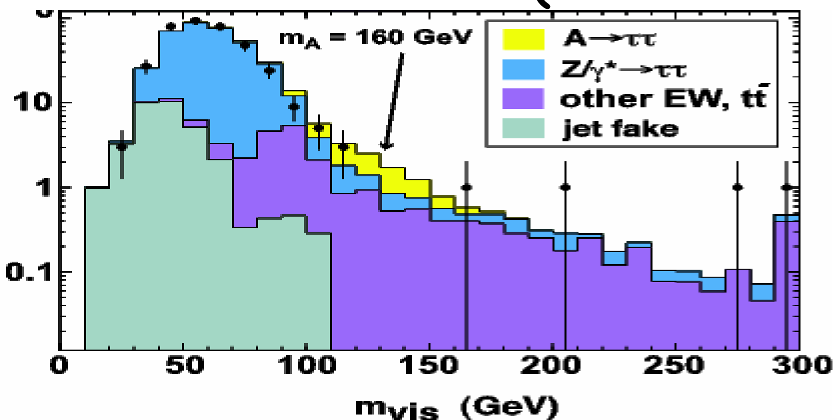
(post Winter Conferences)

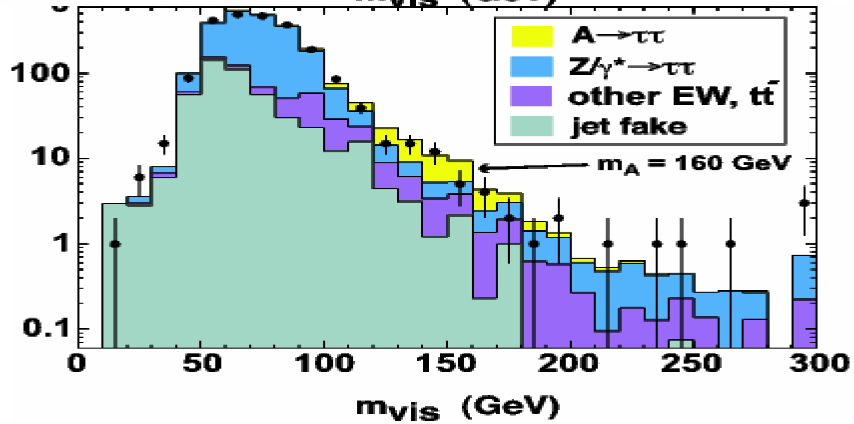
Data used: less than 50% of what on tape by now!

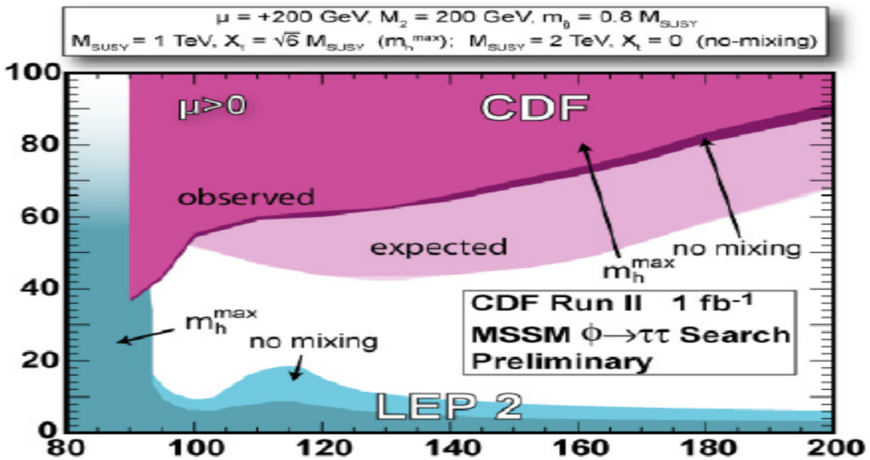
Non SM Higgs

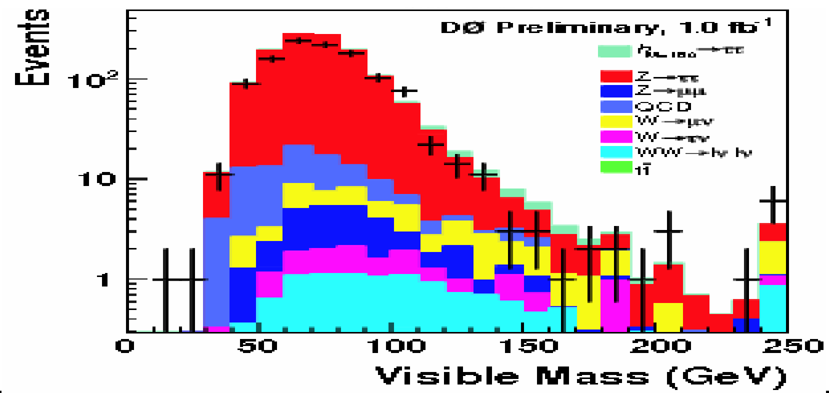
Non SM Higgs(es) have sizeable decay rate to ττ pairs

- Large efforts to bring up efficiency to trigger on tau events (and to detect tau)







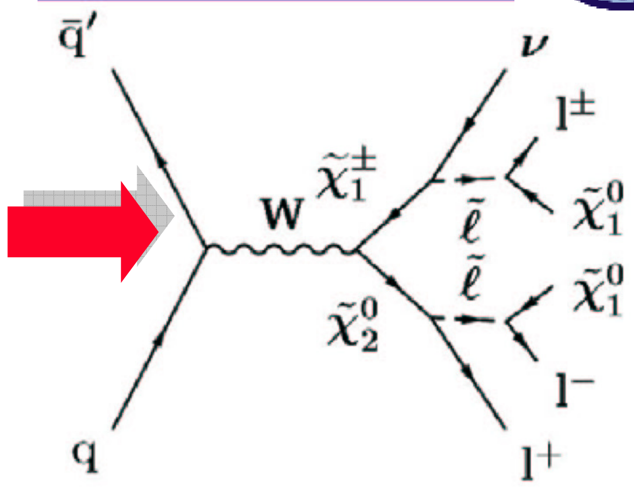


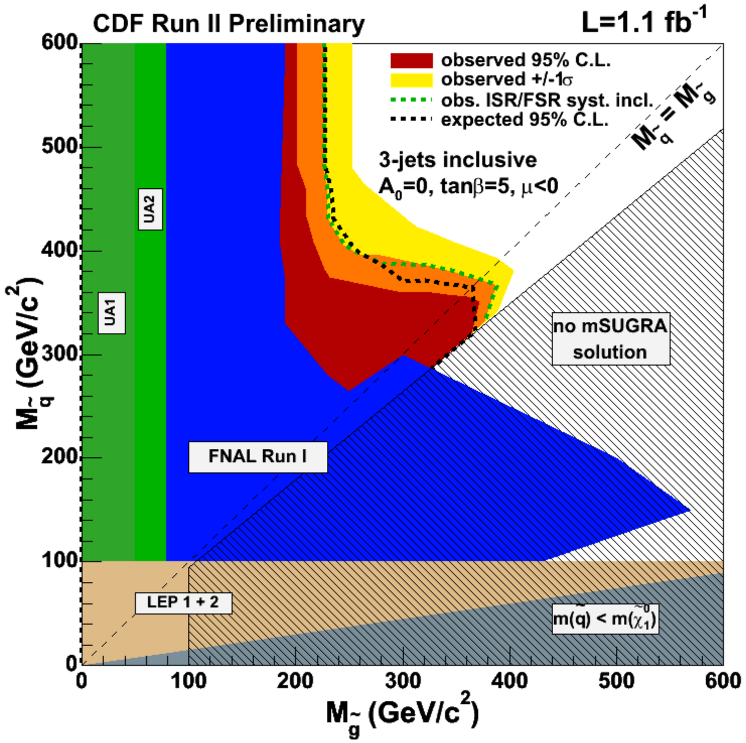
R. Strohemer

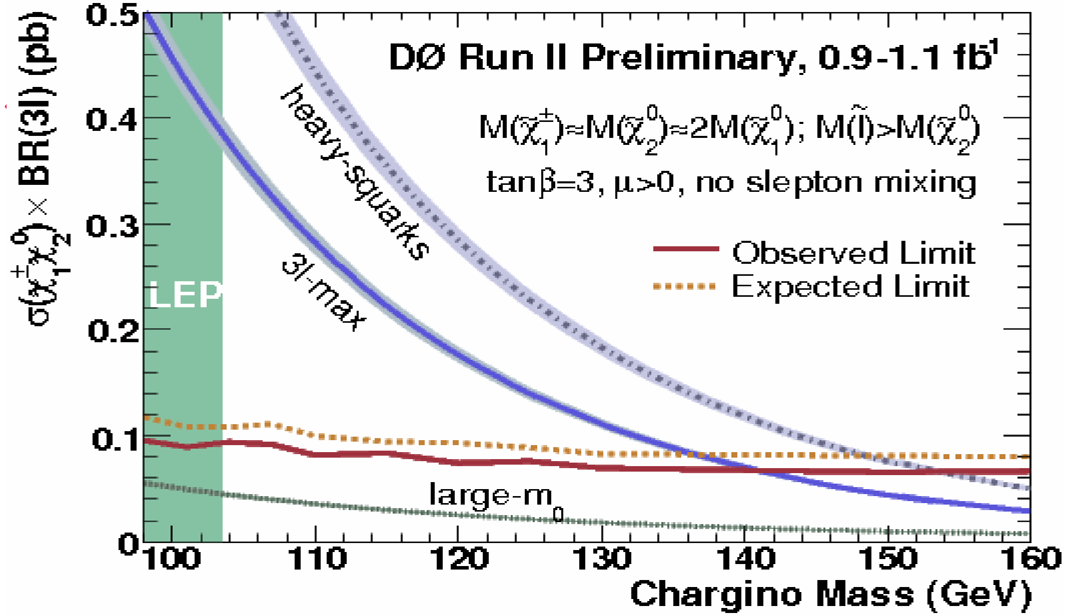
Chargino and Neutralino searches

Both experiments look for SUSY signals

- ☞ Chargino and neutralino are produced with sizeable cross sections
- ☞ More difficult search for squarks and gluinos







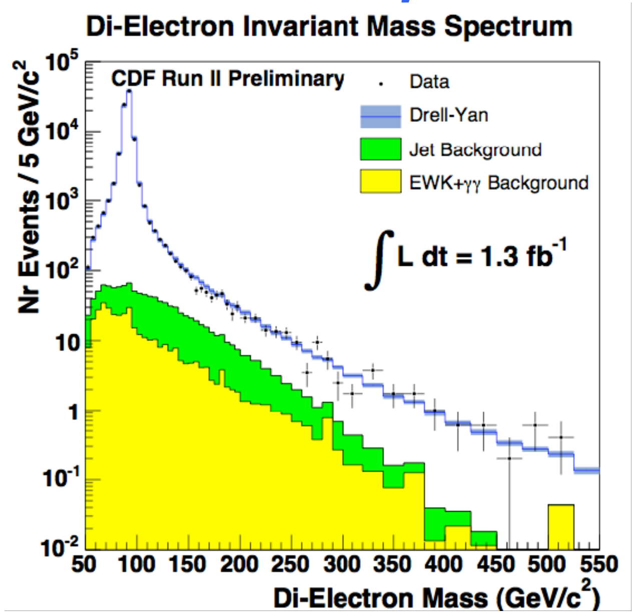
Giorgio Chiarelli, DIS 07

R. Strohemer

More "exotic" searches

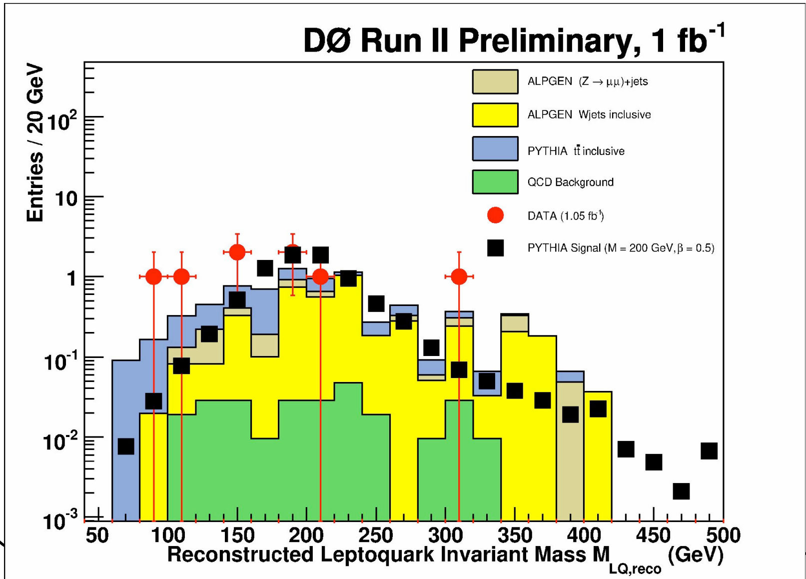
Drell Yan at large masses can be the key

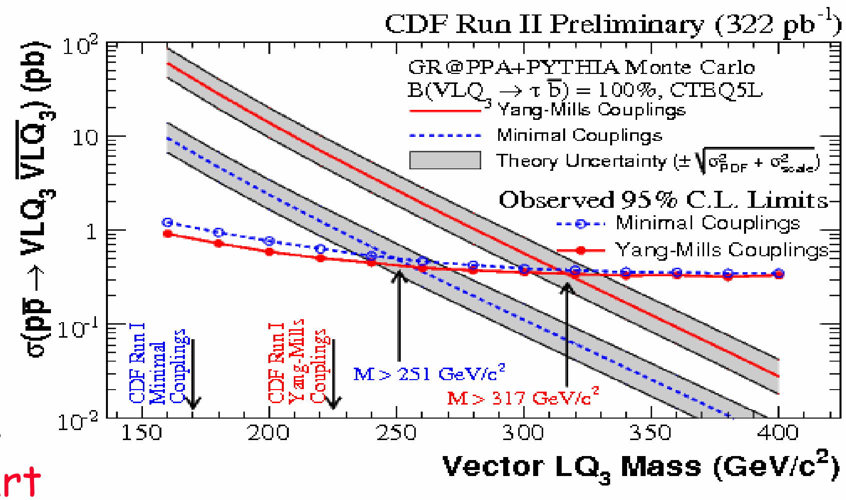
- ☞ Z'→ee at CDF



New limits on LQ

- ☞ 2nd and 3rd generation LQ (pair produced at the Tevatron)





D. Stuart

Conclusion-I

Tevatron experiments are digging a gold mine of $2fb^{-1}$

- The accelerator complex is working well
  - We now collect more data in one week than we used to gather evidence for top
- In the fb region many interesting processes at the boundary of the Standard Model
  - CDF and D0 are well equipped to study physics in this region
- The interest of our program stays in the combination of an accelerator performing well with two well-understood detectors
    - We considerably shortned the time from data taking to publication of results
  - 19 contributions in parallel sessions will discuss the subtleties of many analyses

Conclusion II

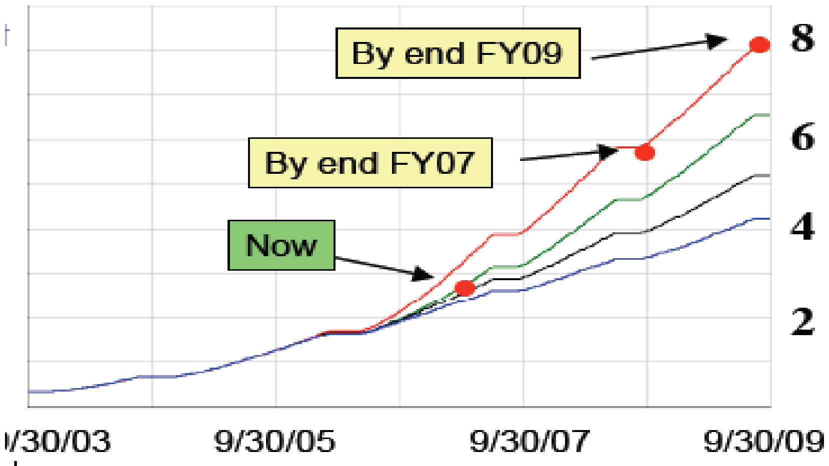
Detectors are performing well

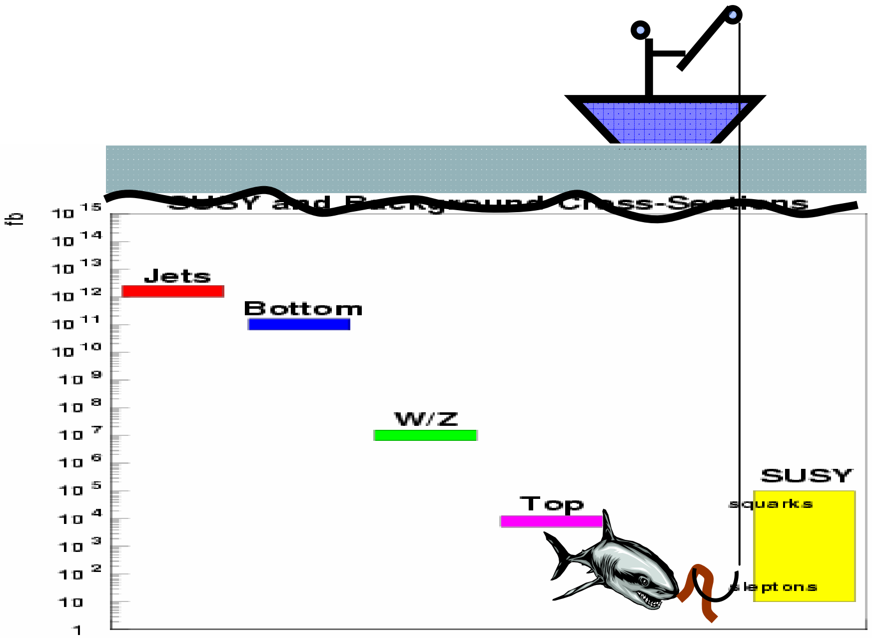
☞Continuous effort

More and more challenging analysis are being performed

☞We are exploring a new region…

⇨The prize?



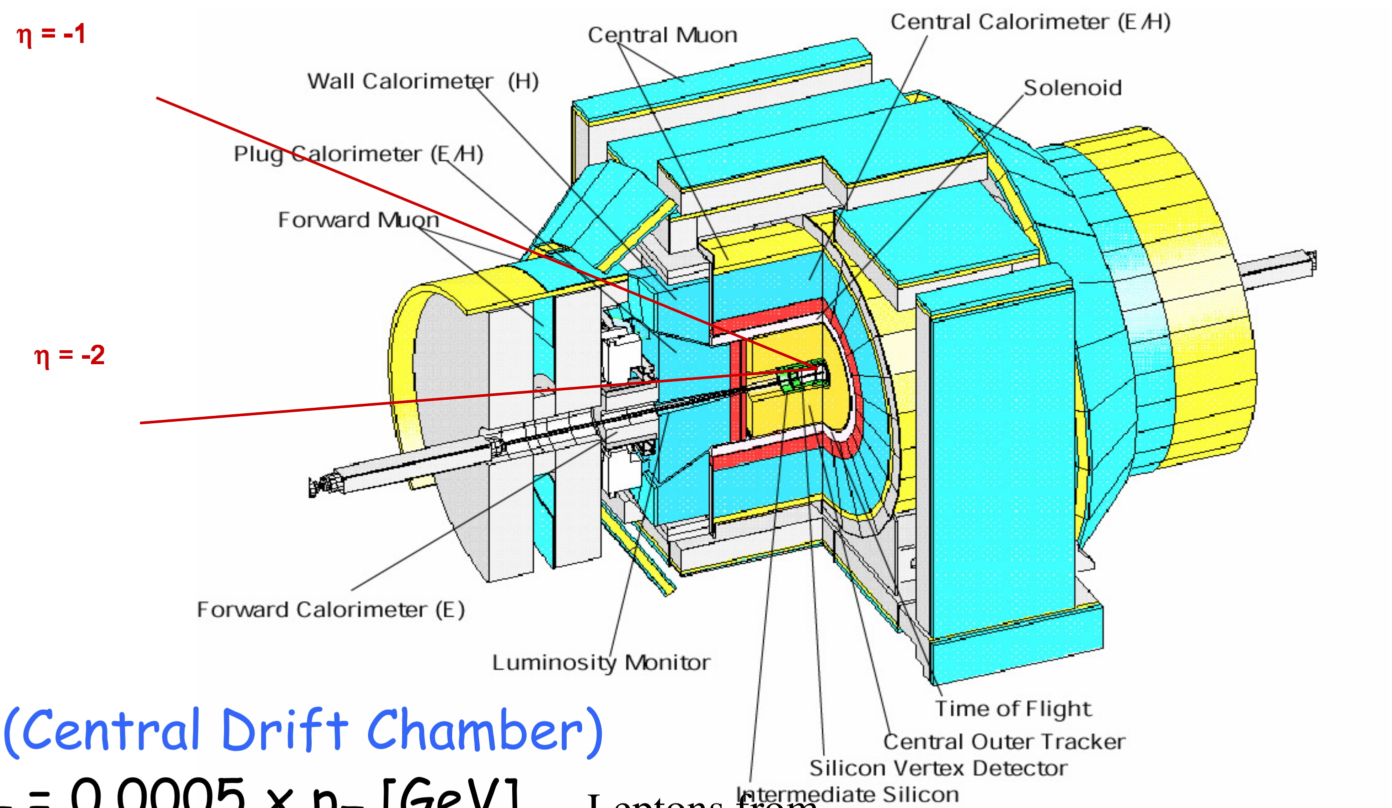


Many thanks to my CDF and D0 colleagues

and to the Organizers

BACKUP

CDF Experiment



Tracking (Central Drift Chamber)

☞ $\delta p_T/p_T = 0.0005 \times p_T$ [GeV]

Leptons from W/Z decays

EM Calorimeter

☞ $\delta E_T/E_T \sim 13.5\% / \sqrt{E_T} \oplus 1.5\%$ [GeV, $|\eta| < 1.1$]

Forward region now used

Detector Status - big picture

Silicon longevity

- Expect silicon detector to last through 2009

Tracking chamber (COT)

- Aging not a problem, will be ok through 2009

High Luminosity running

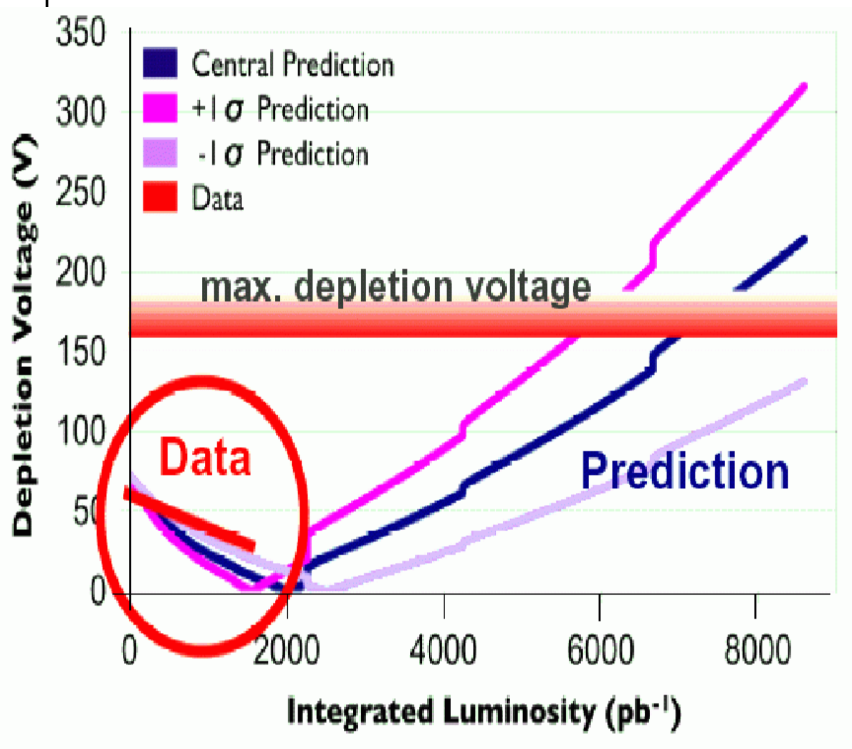
- Trigger
  - Requires constant attention
  - Upgrades on tracking and calorimetry fronts
- DAQ
  - Built more bandwidth
- Physics
  - No significant effect up to 3e32

No showstopper foreseen through FY09

SVX survival

SVX L0 is expected to invert at 2.5 fb^{-1}

- ☞ We are following (so far) this prediction in its optimistic fashion



Technicality:
Vdep studied using both bias vs noise scan and bias vs collected charge scan

- ☞ Both results agree

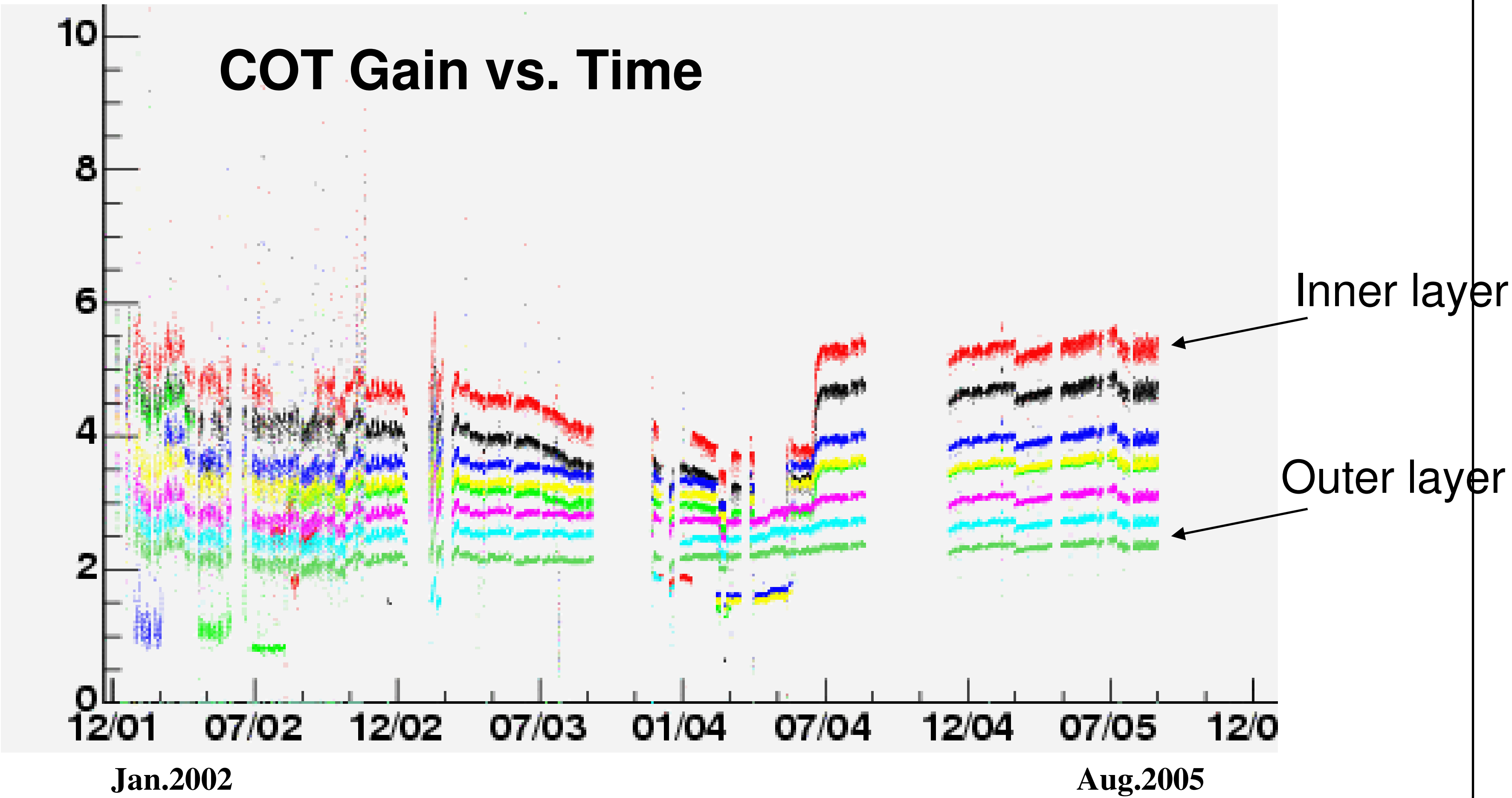
Predizioni 2002

Layer	safe fb^{-1}	cause
0 (SS)	7.4	Vdep
1 (DS)	4.3(5.6)	S/N(Vdep)
2 (DS)	8.5(10.9)	S/N(Vdep)
3 (DS)	10.7	Vdep
4 (DS)	23(30)	S/N(Vdep)
5(DS)	14	Vdep
6(DS)	>40	n/a
7(DS)	> 40	n/a

COT Stability

Since we inserted oxygen

☞COT stable



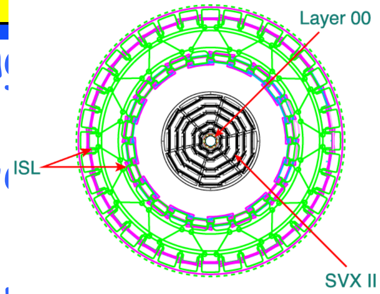
Silicon Longevity - details

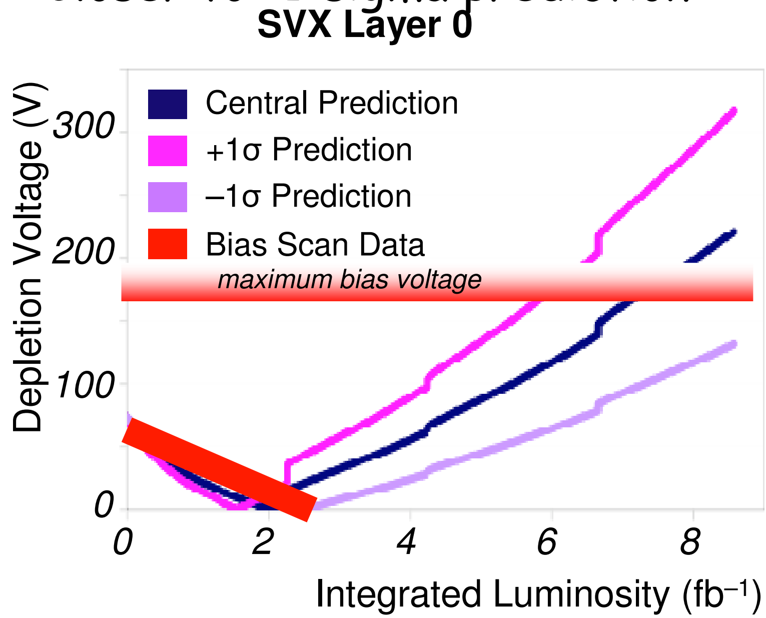
Bias voltage required to fully deplete Silicon sensors chan
with irradiation: decrease – type inversion – increase
If depletion voltage larger than maximum safe bias voltag

☞ cannot fully deplete sensors → efficiency loss

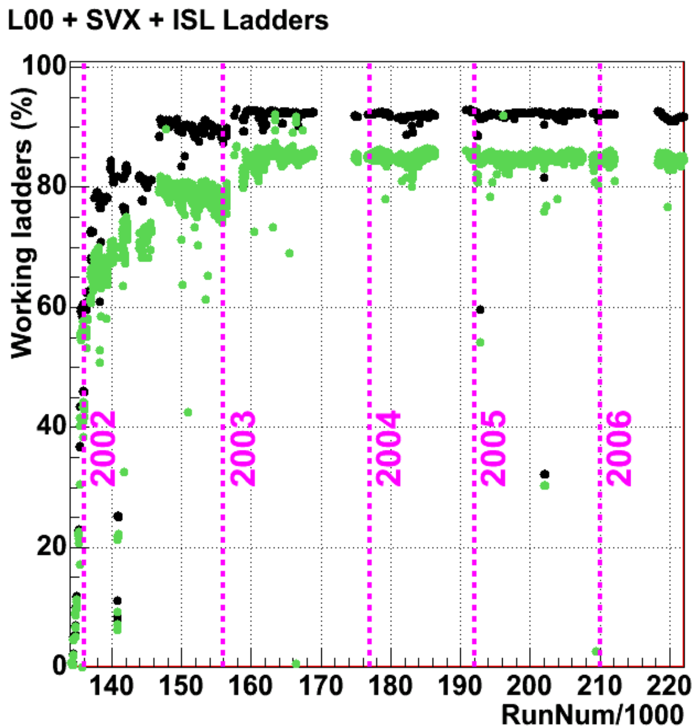
Bias scans show innermost SVX layer (most vulnerable) is nearing inversion

☞ Closer to -1-sigma prediction





Model: S. Worm, *Lifetime of the CDF Run II Silicon*, VERTEX 2003

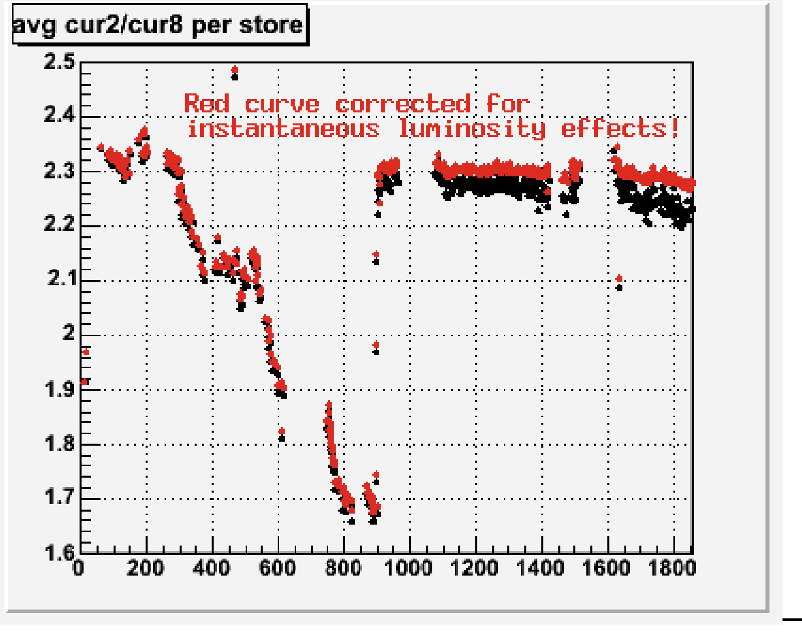


Silicon stable and expected to outlast 8 fb^{-1}

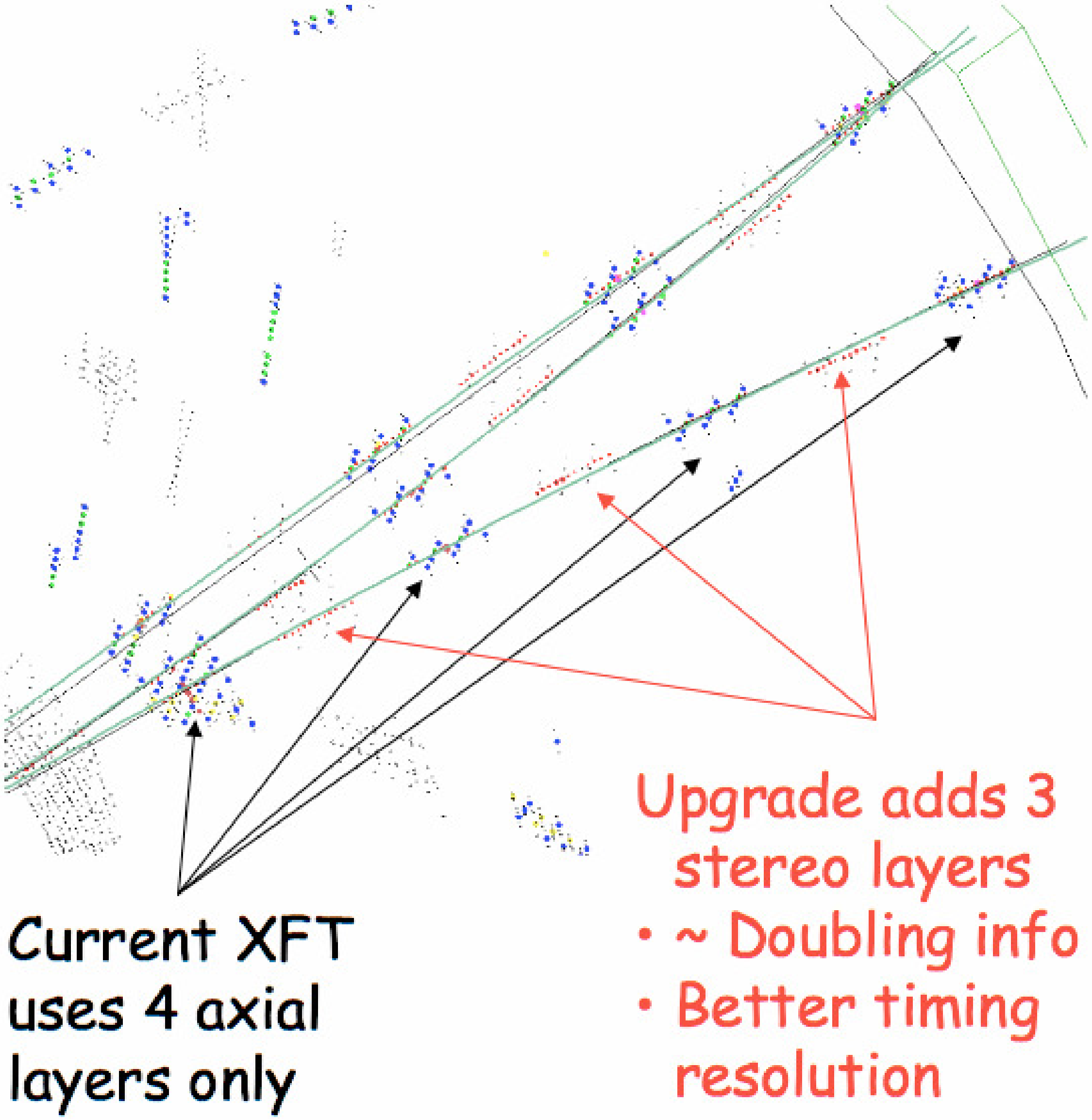
Tracking Chamber - details

We addressed an aging problem of the Central Outer Tracker drift chamber in 2004

- Aging was found to be due to hydrocarbon growth on wires
- Addition of O_2 to gas in June 2004 restored gain to original 2002 levels
- Possible new evidence of aging at the highest luminosities
  - Minimal, if at all
  - New gas purification system to clean re-circulated gas expected to be complete later this year
  - Can also increase amount of oxygen added



XFT Upgrade



XFT originally only utilized axial layers

Upgrade adds 3 stereo layers to 4 layer axial XFT system

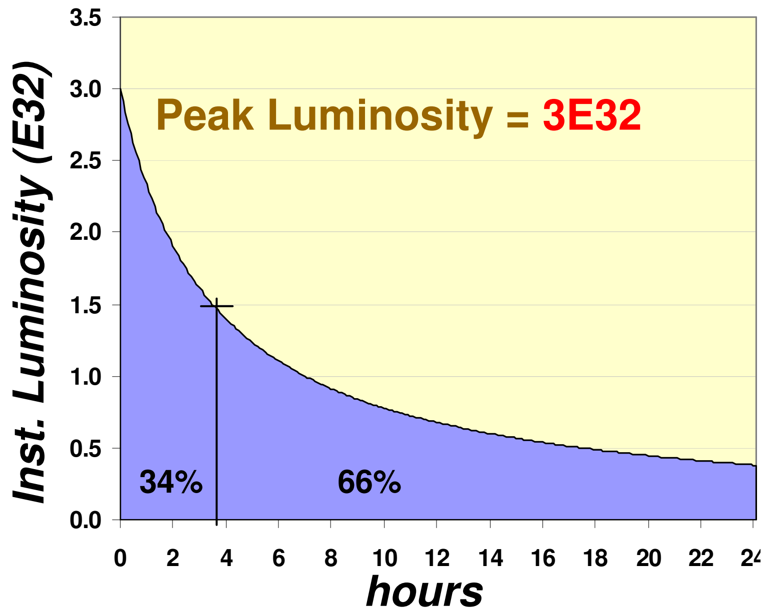
☞ better fake rejection

☞ better resolution

Trigger @ High Luminosity

Experience with luminosity at ~3e32

- Bulk of triggers [for Higgs] are fully functional to at least 3e32
- Identified a few triggers with unacceptable rates
  - XFT and Cal upgrades to help deal with these
- Using "dynamic prescaling" to optimize physics and bandwidth
  - High rate triggers have large prescale at high lum
  - Prescales relaxed as banwidth becomes available at low lum
- Most of the time is spent at below ~1.5e32

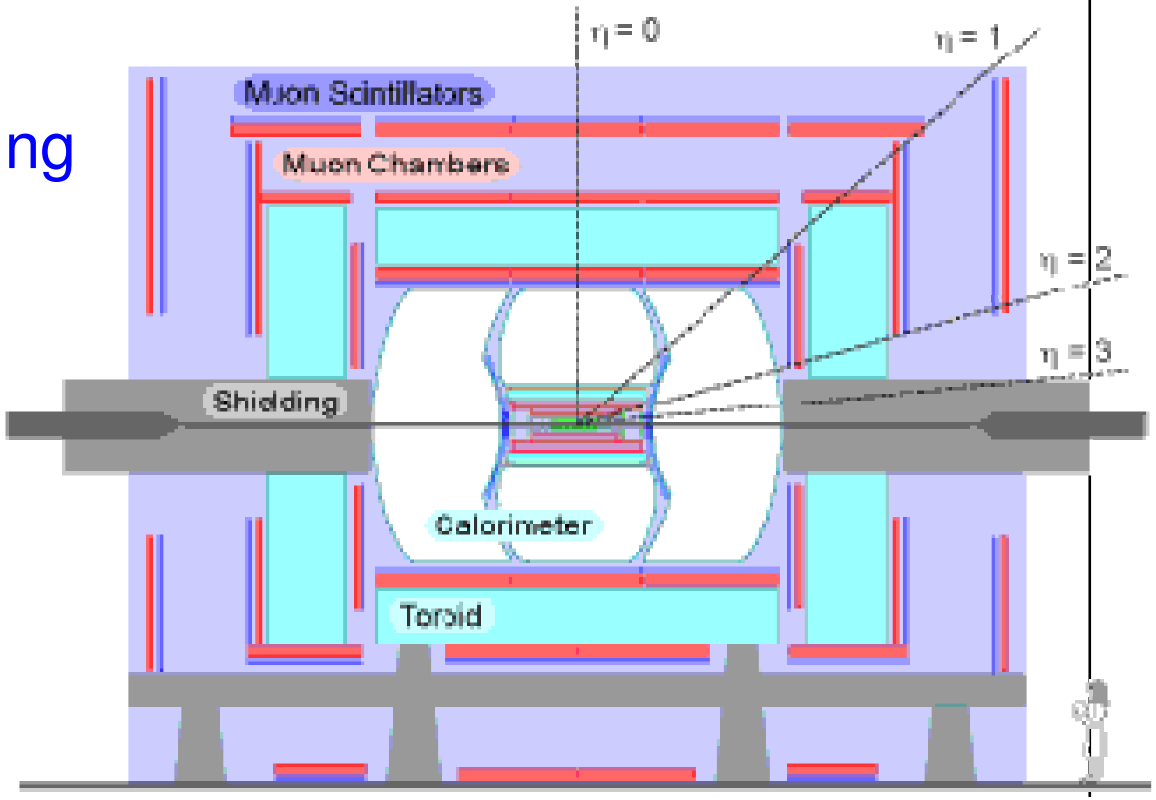


No serious issue but continuous watch is needed

Experiments: DZero (D0)

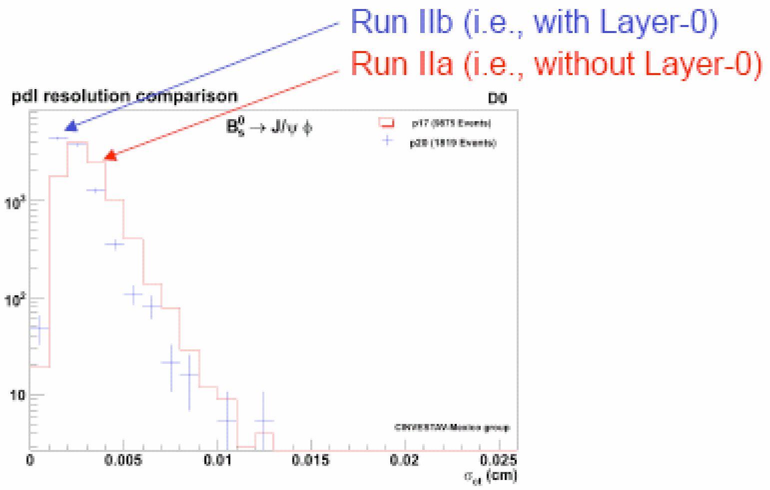
Features:

- Precision silicon vertexing
- Outer Fiber Tracker
  (r=0.5m)
- 2.0 T solenoid
- EM+HAD Calorimetry
- muon chambers
  ($|\eta| < 2.0$)

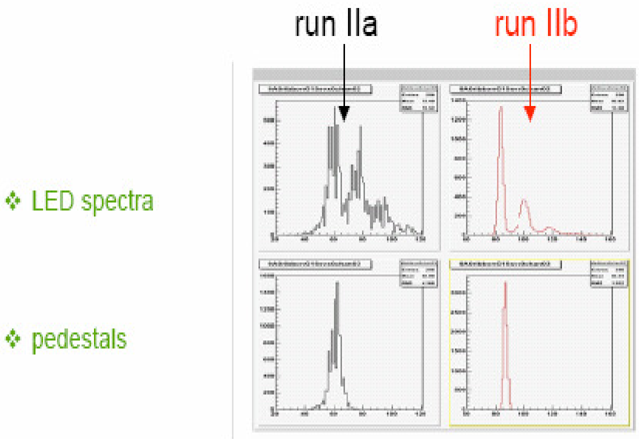


D0 IIb upgrades

- Tracking: Layer-0 Silicon Detector
  - 19 bad channels (out of total of 12,288 channels)
  - Signal to noise is ~15 to 1
    - No significant coherent noise
  - Improvement in decay length resolution



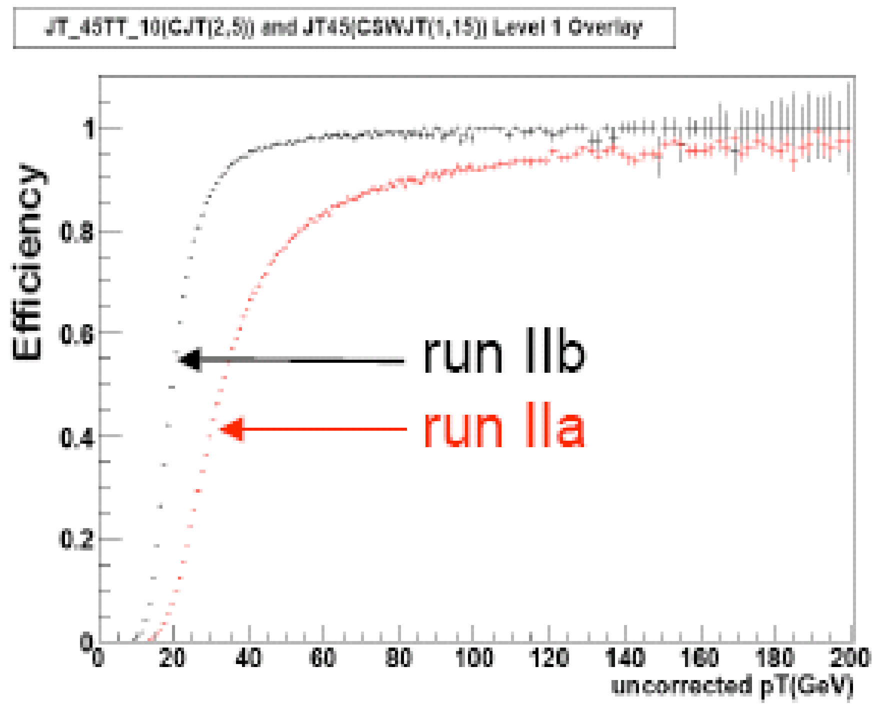
- Tracking: AFE-IIt readout boards for fiber tracker
  - Eliminates amplifier saturation at high luminosity
  - Substantially improves pulse height resolution
    - ➢ optimization of VLPC bias voltages and reduced thresholds



D0 IIb upgrades

- Level-1 Trigger: Calorimeter
  - Complete replacement of 10 racks of run I electronics
  - Allows electron, tau and jet clustering at Level-1
    - ➢ Sharper turn-on curves!

❖ e.g. 45 GeV jet trigger

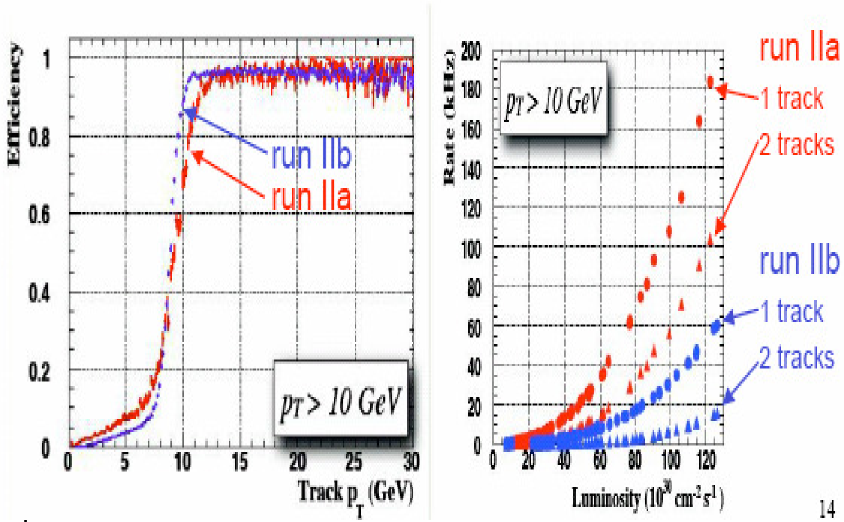


D0 IIb upgrades

Triggering at L1

- Level-1 Trigger: Tracking
  - More sophisticated algorithm requiring larger FPGAs

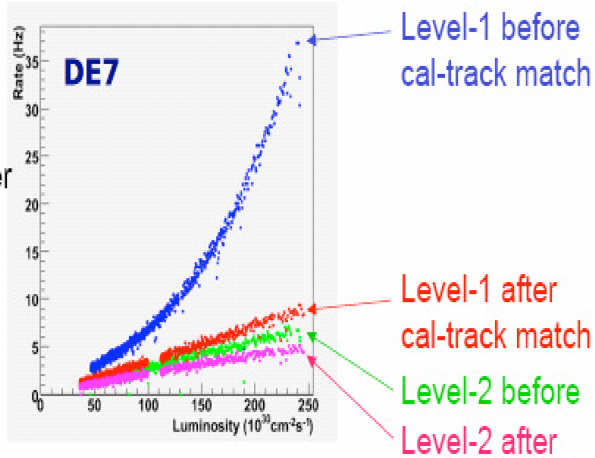
➢ sharper turn-on   lower fake rates



- Level-1 Trigger: Calorimeter-Track Matching
  - Entirely new capability for DØ at Level-1
    - formerly available only at Level-2

  ➢ Improved rejection and linearity with luminosity

E.g., 7 GeV di-electron trigger



Openings of new physics capabilities!

The machine

The basic is a good, working accelerator

- ☞At the moment excellent performance of
  - ⇨8 different machines (e-cooling included)

We are working with a goal of integrated luminosity

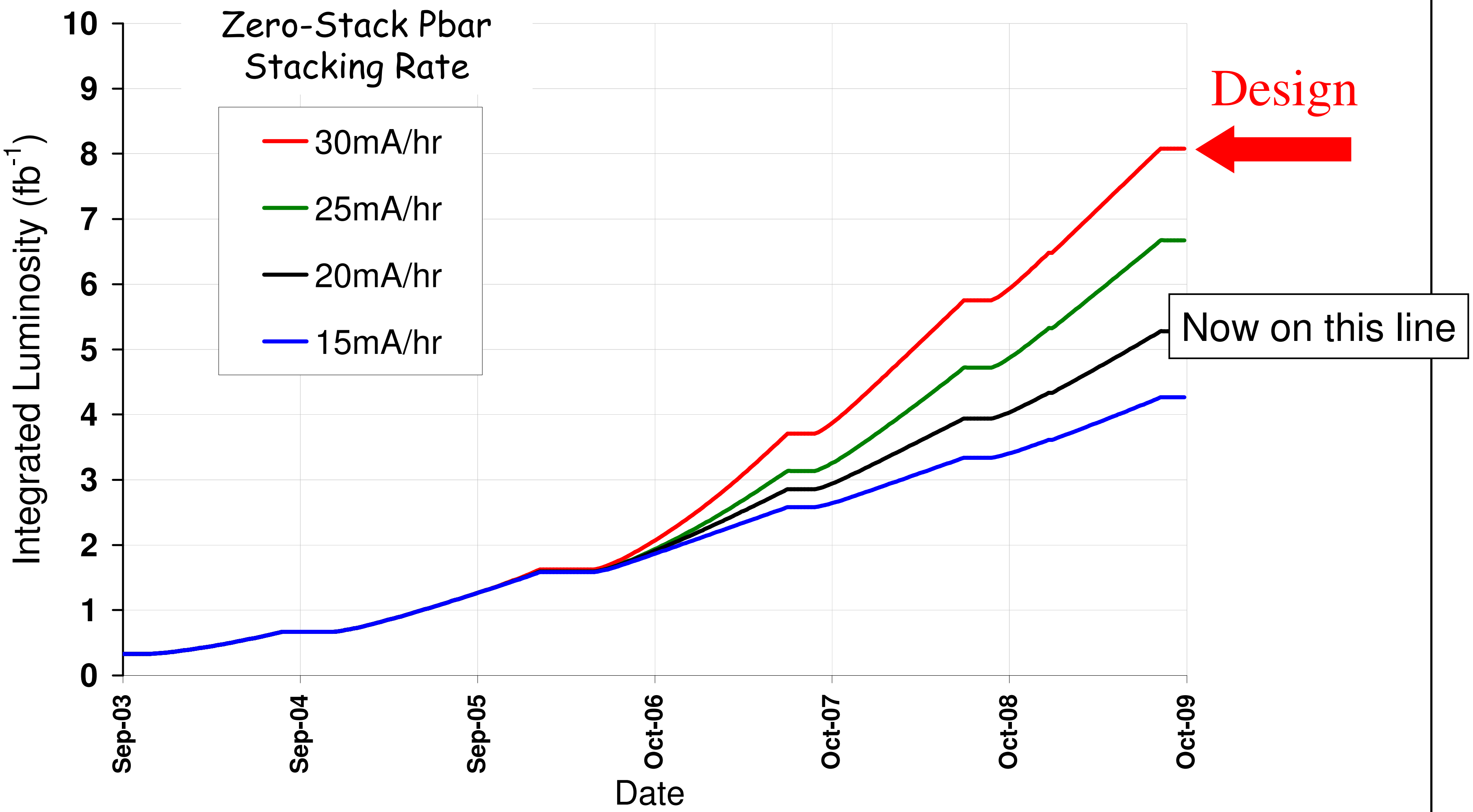
- ☞~8 fb^{-1}/esperimento by FY09
  - ⇨Dubbed *Design*

and a "fallback position"

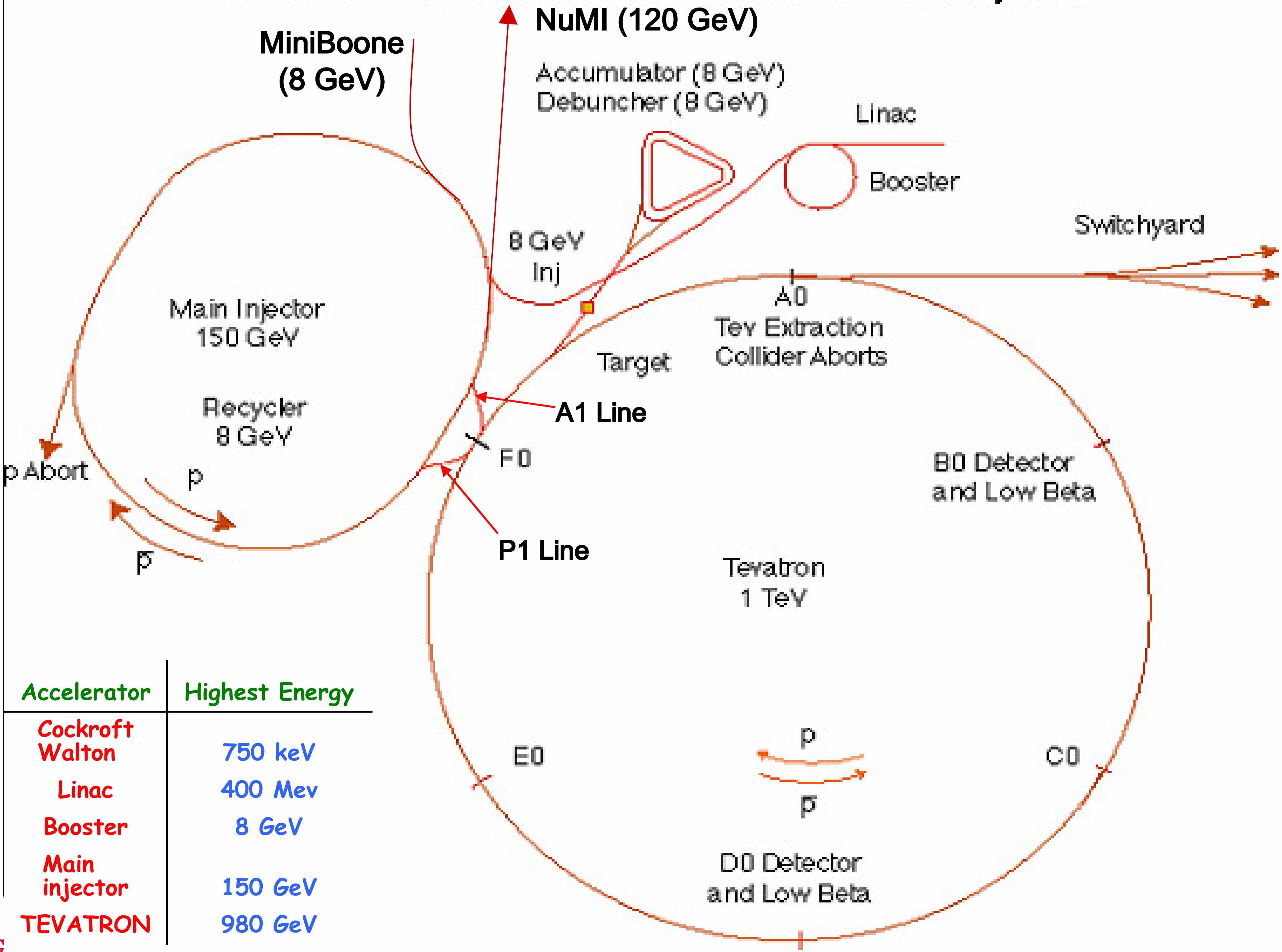
- ☞~4.5 fb^{-1}/experiment by FY 09
  - ⇨a.k.a. "baseline"

I would like to thank the BD people for an outstanding job, and for their day by day efforts

Run II Luminosity Projections



FermilabTevatron Accelerator With Main Injector



Accelerator	Highest Energy
Cockroft Walton	750 keV
Linac	400 Mev
Booster	8 GeV
Main injector	150 GeV
TEVATRON	980 GeV

Luminosity Formula

$$L = \frac{fN_p N_a}{2\pi(\varepsilon_p + \varepsilon_a)\beta^*} H\left(\sigma_z \big/ \beta^*\right)$$

N = bunch intensity, f = collision frequency
ε = transverse emittance (size), σ_z = bunch length
H = "hour glass" factor (<1, accounts for beam size over finite bunch length)

<u>Increasing the Luminosity</u>

Smaller β* (new 28 cm β* lattice in Sep 05)
Larger N_a and smaller ε_a from Recycler + electron cooling

Projection for 30 mA/hr stack rate

Luminosity Parameters							
Phase	1	2	3	4	5	6	
Initial Luminosity	77.0	97.1	137.2	318.9	331.2	331.2	$x10^{30}cm^{-2}sec^{-1}$
Average Luminosity	33.8	45.3	64.0	128.0	132.9	132.9	$x10^{30}cm^{-2}sec^{-1}$
Integrated Luminosity / week	12.1	16.5	23.3	48.2	50.1	50.1	pb^{-1}
Integrated Luminosity / store	3.0	3.6	5.1	10.1	10.5	10.5	pb^{-1}
Number of stores / week	4.0	4.6	4.6	4.8	4.8	4.8	
Average Store Hours / week	100	101	101	105	105	105	Hours
Store Length	25	22	22	22	22	22	Hours
Initial Lifetime	6.4	6.4	6.4	5.0	5.0	5.0	Hours
Average Lifetime	12.8	12.3	12.3	9.9	9.9	9.9	Hours
HEP Up Time / week	110	113	113	117	117	117	Hours
Shot Setup Time	2.6	2.6	2.6	2.6	2.6	2.6	Hours

Now entering phase 4

Projection for 30 mA/hr stack rate

60% increase

Antiproton Parameters							
Phase	1	2	3	4	5	6	
Zero Stack Stacking Rate	13.0	16.0	18.9	30.2	30.2	30.2	$x10^{10}$/hour
Average Stacking Rate	6.3	7.4	9.6	21.7	21.7	21.7	$x10^{10}$/hour
Stack Size transferred	158.2	163.8	211.5	476.5	476.5	476.5	$x10^{10}$
Stack to Low Beta	117.1	124.5	169.2	381.2	381.2	381.2	$x10^{10}$
Pbar Production	16.0	15.0	16.0	21.0	21.0	21.0	$x10^{-6}$
Protons on Target	5.4	6.5	7.2	8	8	8	$x10^{12}$
Pbar cycle time	2.4	2.2	2.2	2	2	2	Secs.
Pbar up time fraction	0.75	0.75	0.75	0.9	0.9	0.9	
Initial Stack Size	15	15	0	0	0	0	$x10^{10}$
Stack Size at 1/2 Stacking Rate	150	150	150	150	150	150	$x10^{10}$

FY04

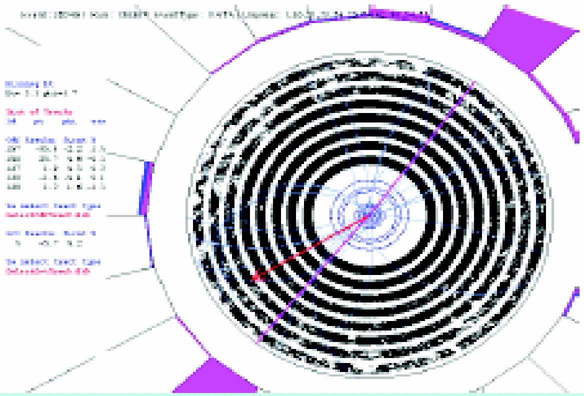
Slip Stack

Ecool

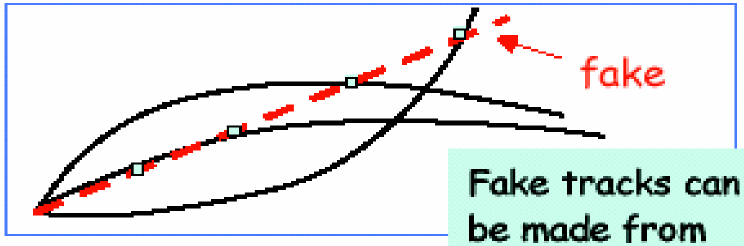
Stack tail

Saving Private Higgs

Maintain existing triggers Fake triggers at High Lumi

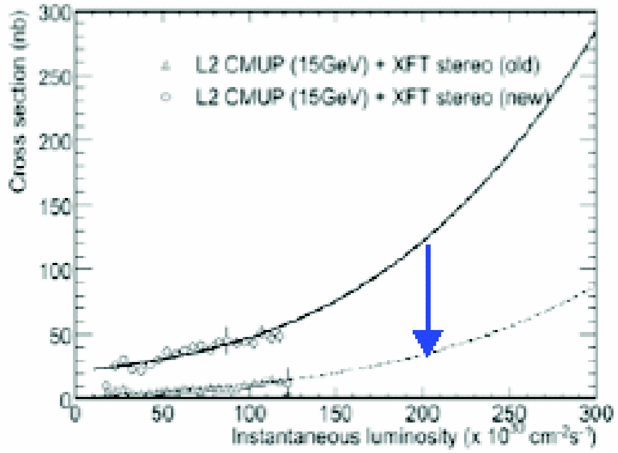


View of a Z → ee at low lum. looking down the beampipe
8 add. Interactions/crossing ~ 300 $cm^{-2}s^{-1}$



Fake tracks can be made from segments of different real physical tracks.

Trigger σ for muons increases to third power!



Defense:

Upgrading track trigger from 2-D to 3-D

- Makes use of stereo tracking layers

Cuts down fake muons by factor of 5 !

- Installation and commission this winter

W mass measurement strategy

W mass obtained from fit of transverse mass $M_T(l\nu)$

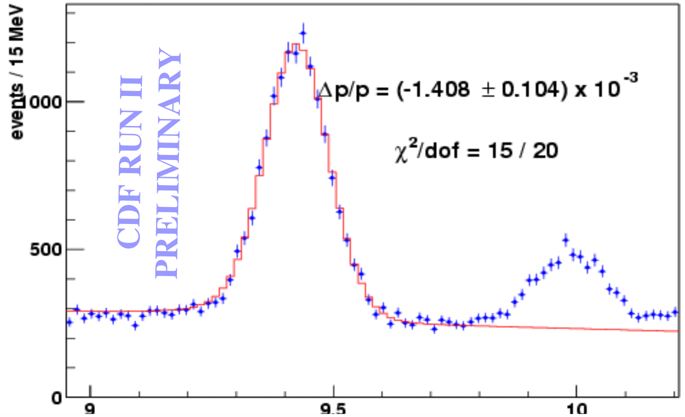
use Z events to model detector response to hadronic recoil energy and calibrate the charged lepton resolution

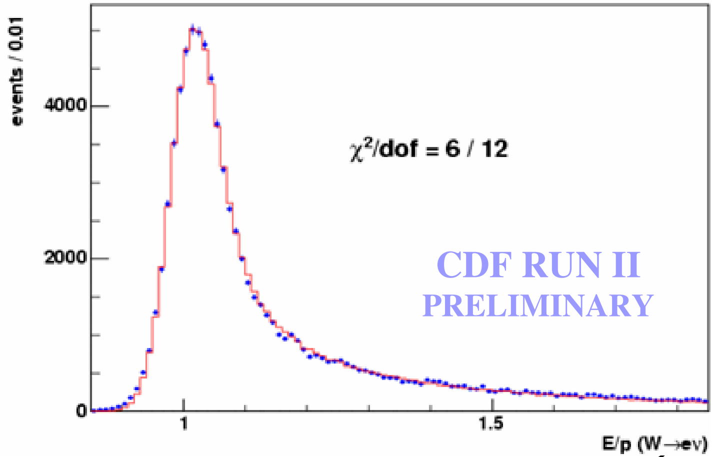
obtain charged lepton scale using

- ☞ J/ψ + Upsilon mass for momentum scale
- ☞ E/p in W events for energy scale (greater stat. precision than Z)
- ☞ use Z events to cross check

W production model:

- ☞ Use Z decay to model boson p_T distr.
- ☞ QED corrections to W/Z decay
- ☞ QCD corrections to W/Z production
- ☞ Will use next PDFs fits with CDF W asymmetry measurement





W mass uncertainties

Three fits (MT, PTe, MET)

CDF II preliminary — **L = 200 pb^{-1}**

MET Uncertainty [MeV]	Electrons	Muons	Common
Lepton Scale	30	17	17
Lepton Resolution	9	5	0
Recoil Scale	15	15	15
Recoil Resolution	30	30	30
$u_{\parallel}$ Efficiency	16	13	0
Lepton Removal	16	10	10
Backgrounds	7	11	0
$p_T(W)$	5	5	5
PDF	13	13	13
QED	9	10	9
Total Systematic	54	46	42
Statistical	57	66	0
Total	79	80	42

CDF II preliminary — **L = 200 pb^{-1}**

p_T Uncertainty [MeV]	Electrons	Muons	Common
Lepton Scale	30	17	17
Lepton Resolution	9	3	0
Recoil Scale	17	17	17
Recoil Resolution	3	3	3
$u_{\parallel}$ Efficiency	5	6	0
Lepton Removal	0	0	0
Backgrounds	9	19	0
$p_T(W)$	9	9	9
PDF	20	20	20
QED	13	13	13
Total Systematic	45	40	35
Statistical	58	66	0
Total	73	77	35

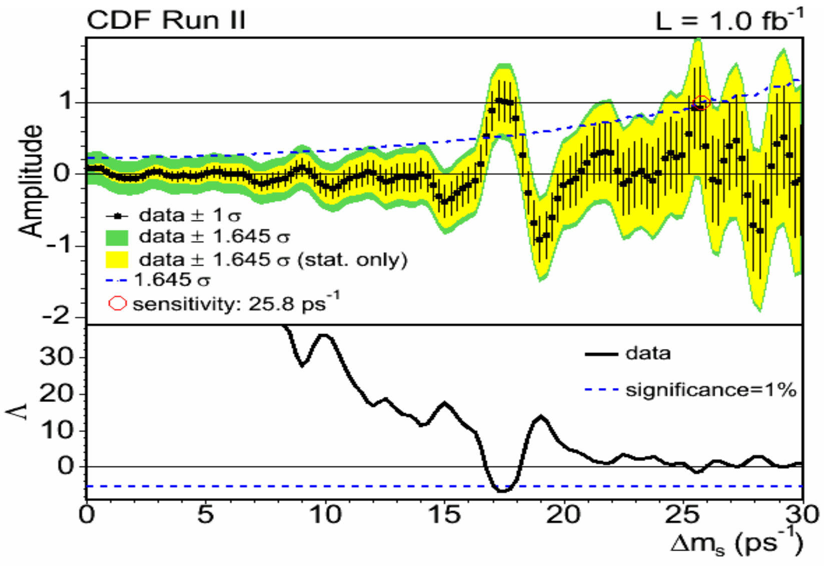
CDF II preliminary — **L = 200 pb^{-1}**

m_T Uncertainty [MeV]	Electrons	Muons	Common
Lepton Scale	30	17	17
Lepton Resolution	9	3	0
Recoil Scale	9	9	9
Recoil Resolution	7	7	7
$u_{\parallel}$ Efficiency	3	1	0
Lepton Removal	8	5	5
Backgrounds	8	9	0
$p_T(W)$	3	3	3
PDF	11	11	11
QED	11	12	11
Total Systematic	39	27	26
Statistical	48	54	0
Total	62	60	26

Bs oscillations

CDF presented "Evidence" (
few months ago

- ☞ $\Delta m_s = 17.31^{+0.33}{}_{0.18}$(stat) ± 0.07(syst)
- ☞ Do you remember Top?

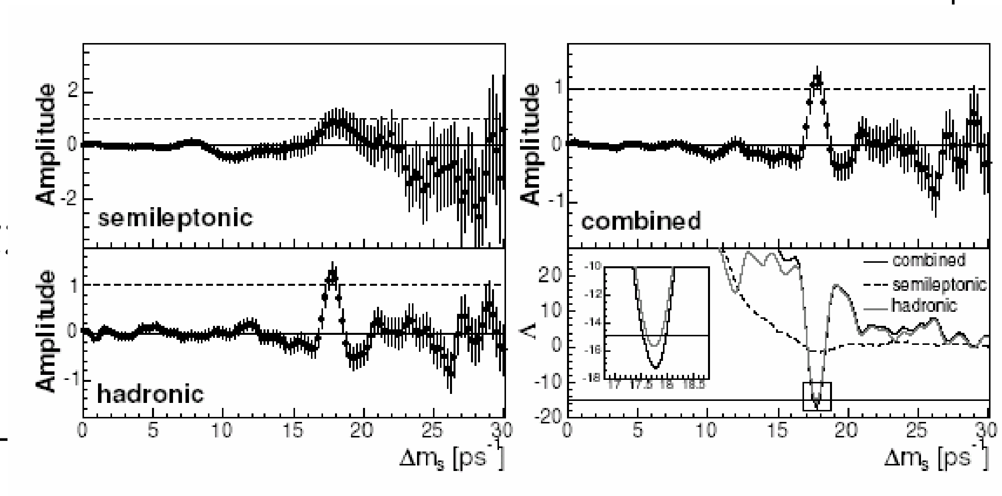


Now with a full dataset of $1 fb^{-1}$ we present

- ☞ Observation of B_s Oscillation

Submitted to PRL on Sept. 18

- ☞ Δm_s=17.77 $\pm$0.10(stat)$\pm$0.07(syst) > 5σ Observation
- ☞ Migliore selezione
- ☞ Aggiunti alcuni canali
- ☞ Migliorato il tagging, utiliz OS Kaon tagging



Improvements

Official table spring 06

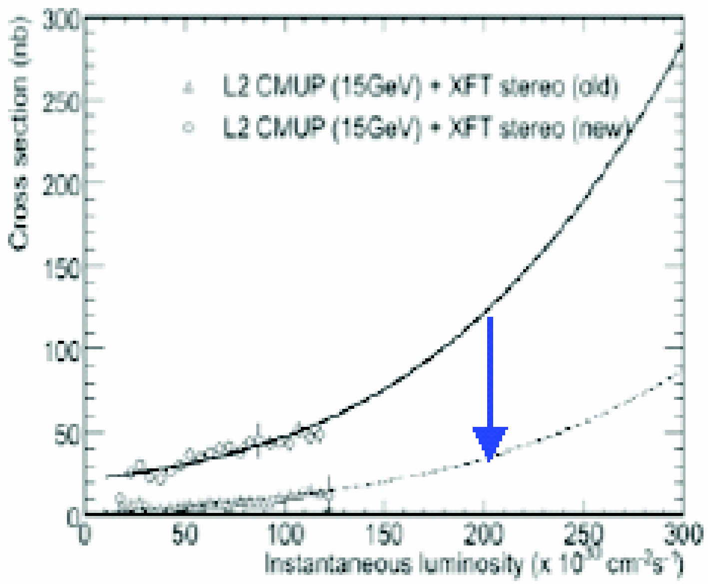
Luminosity Equivalent $(s/\sqrt{b})^2$

Improvement	WH→lνbb	ZH→ννbb	ZH→llbb
Mass resolution	**1.7**	**1.7**	**1.7**
Continuous b-tag (NN)	1.5	1.5	1.5
Forward b-tag	1.1	1.1	1.1
Forward leptons	1.3	1.0	1.6
Track-only leptons	1.4	1.0	1.6
NN Selection	**1.75**	**1.75**	**1.0**
WH signal in ZH	**1.0**	**2.7**	**1.0**
Product of above	8.9	13.3	7.2
CDF+DØ combination	2.0	2.0	2.0
All combined	17.8	26.6	14.4

Now we have H→WW(*) ....

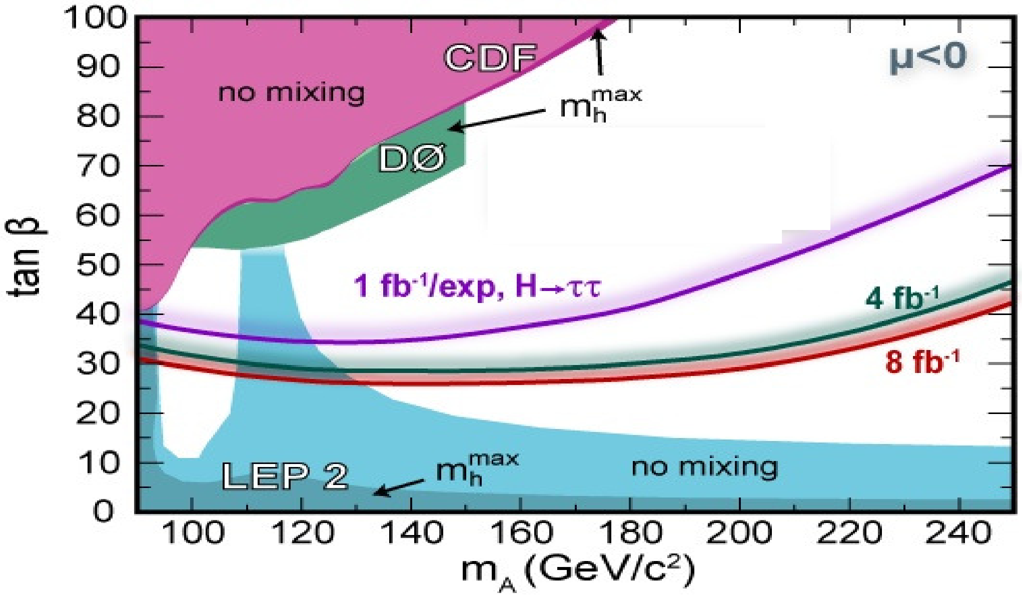
However there are some problems to be dealt with:

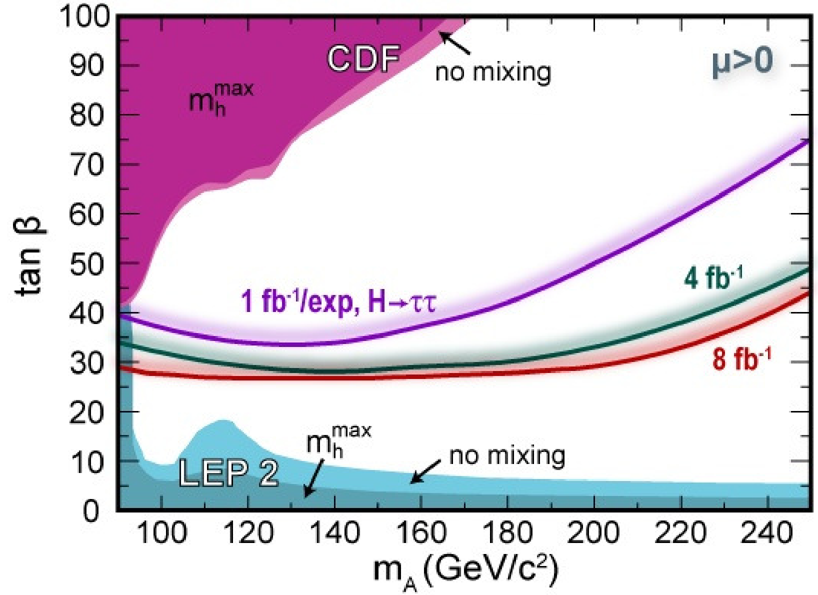
- ☞ Trigger for μ at high lum (taken care of by XFT upg.)

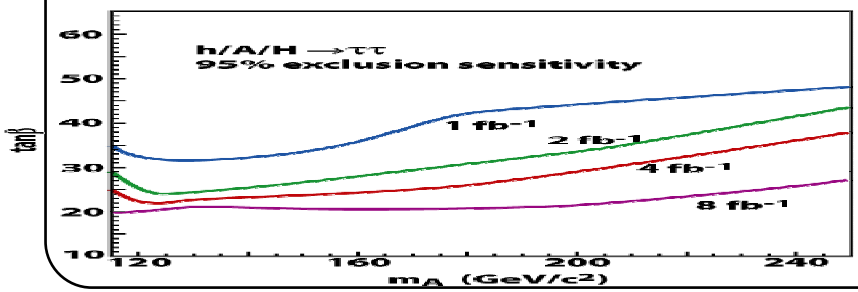


MSSM Higgs

- ☞BF(H→ ττ) is large
  - ⇨(benchmark:Z→ττ)







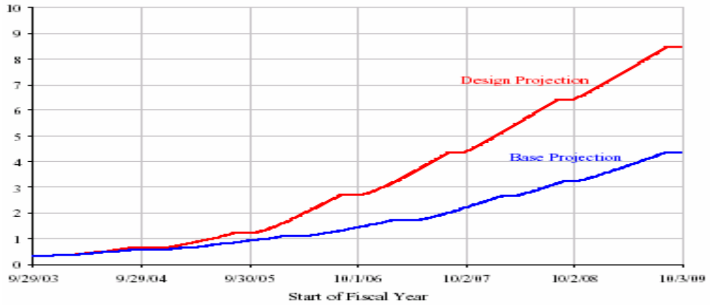
Tevatron is able to search a MSSM higgs for tanβ>30 and M_A<200 GeV/c²

Slide from 2004

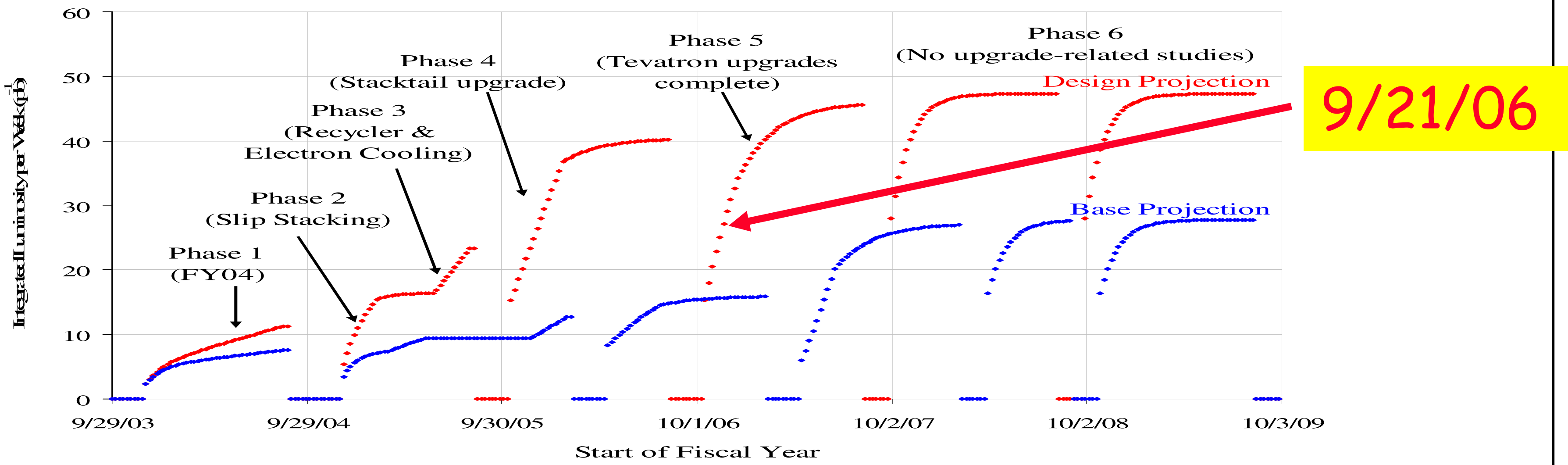
Chiarelli, IFAE 2004

Machine is performing…in the future:

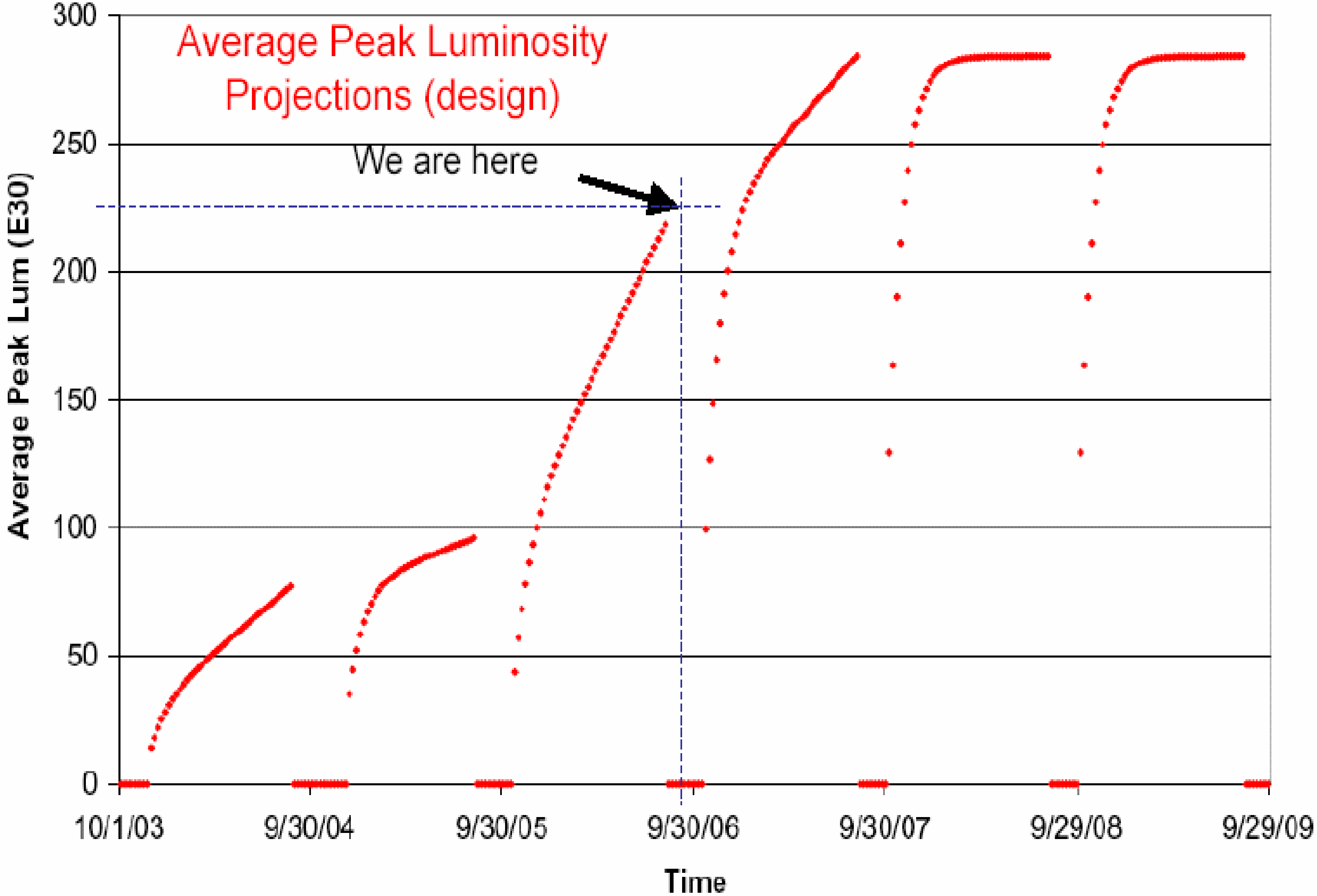
- ☞ CDF &D0, designed for 132 ns
  - ⇨ will have to work at 396 and ~2.7×10^{32} $cm^{-2}s^{-1}$



Fiscal Year	Design (fb^{-1})	Base (fb^{-1})
FY03	0.33	0.33
FY04	0.64	0.56
FY05	1.2	0.93
FY06	2.7	1.4
FY07	4.4	2.2
FY08	6.4	3.3
FY09	8.5	4.4



How is the Tevatron performing?



B→ hh - II

Con 1 fb-1 si osserva per la prima volta

- $B_s \to K\pi$

$$BR(B_s^0 \to K^-\pi^+) = (5.0 \pm 0.75\,(stat.) \pm 1.0\,(syst.)) \times 10^{-6}$$

- Misuriamo ACP (SM: ~50%):

$$A_{CP} = \frac{N(\overline{B}_s^0 \to K^+\pi^-) - N(B_s^0 \to K^-\pi^+)}{N(\overline{B}_s^0 \to K^+\pi^-) + N(B_s^0 \to K^-\pi^+)} = 0.39 \pm 0.15\,(stat.) \pm 0.08\,(syst.)$$

- We can test SM predictions:

Is observed CP violation in $B_d \to K\pi$ due to new physics? Check SM prediction of equal violationin $B_s \to K\pi$, PLB 261(2005), 126

Precision measurements

Prod x-sect for W e Z

☞ σ(W) at large η, Z→ ττ

Forward W cross section (CDF)

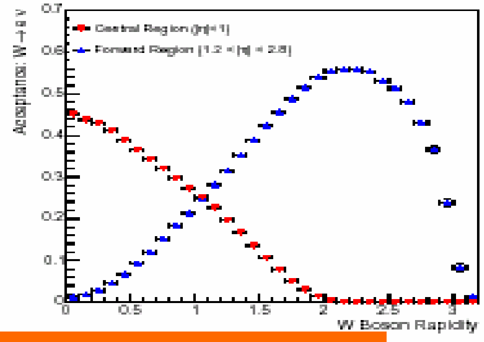
Similar to Z rapidity, a comparison of W cross section from central and forward electrons constrains W production model

- longitudinal momentum distribution of W boson is important because acceptance affects couples this to observed transverse momentum distribution

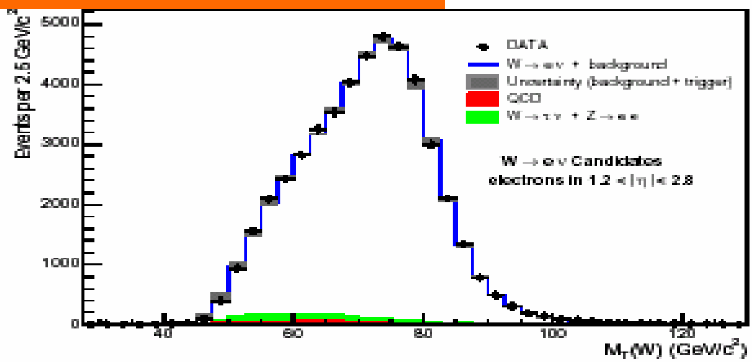
$$R_{\text{exp}}^{central\,/\,forward} = 0.925 \pm 0.033$$

$$R_{CTEQ\ 6.1}^{central\,/\,forward} = 0.924 \pm 0.037$$

$$R_{MRST\,01E}^{central\,/\,forward} = 0.941 \pm 0.012$$

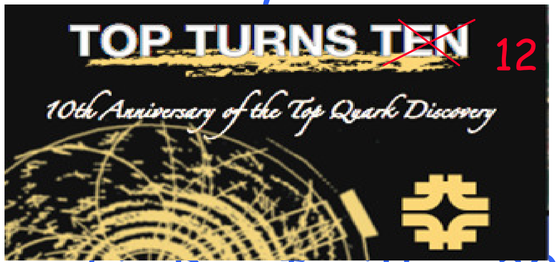


CDF 223 pb⁻¹ preliminary



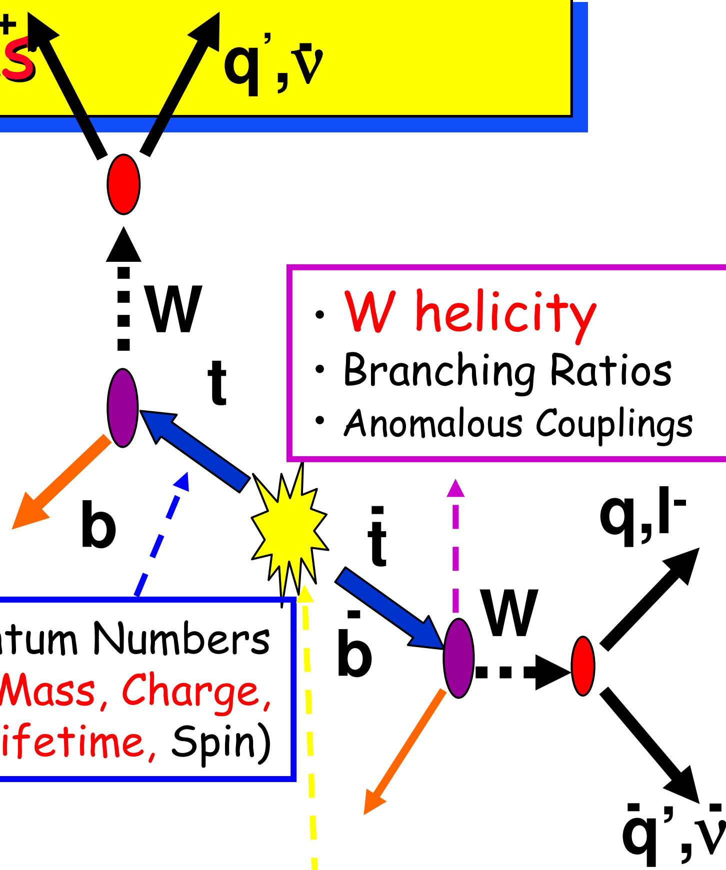
Top Physics

Can be studied only at Tevatron so far.



- Discovered in Run I with ~30 evts/experiment (L=110 pb^{-1})
- RunII>2fb-1/experiment on tape
- Large mass ~170 GeV
  - ☞ Special role in EWSB?
  - ☞ Probe to physics beyond SM
- Top lifetime ~10^{-25} sec (Γ=1.5 GeV) -> no time to hadronize -> can probe charge and spin of bare quark!
- With 1 fb^{-1} we want to answer:

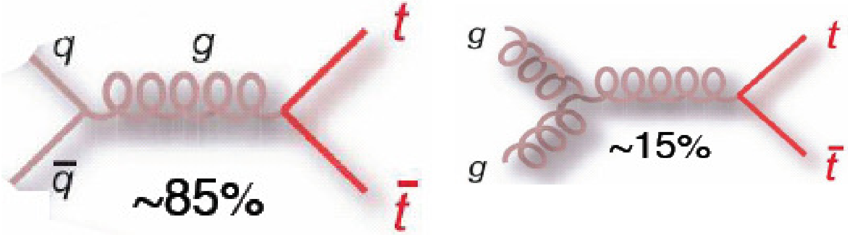
"Is it SM top?"



- W helicity
- Branching Ratios
- Anomalous Couplings

Top Quantum Numbers (Mass, Charge, Lifetime, Spin)

Production cross-section
Production Kinematics



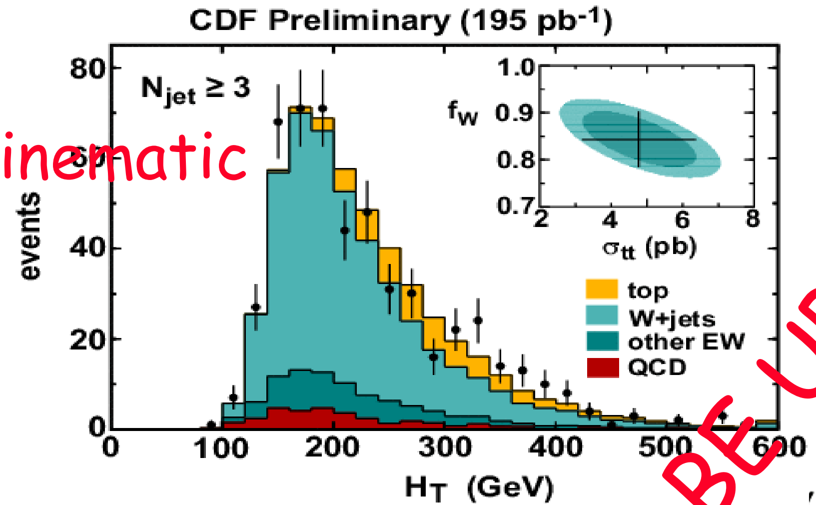
See: C.Gerber, J.Wagner, S.Jabeen,

Top x-section

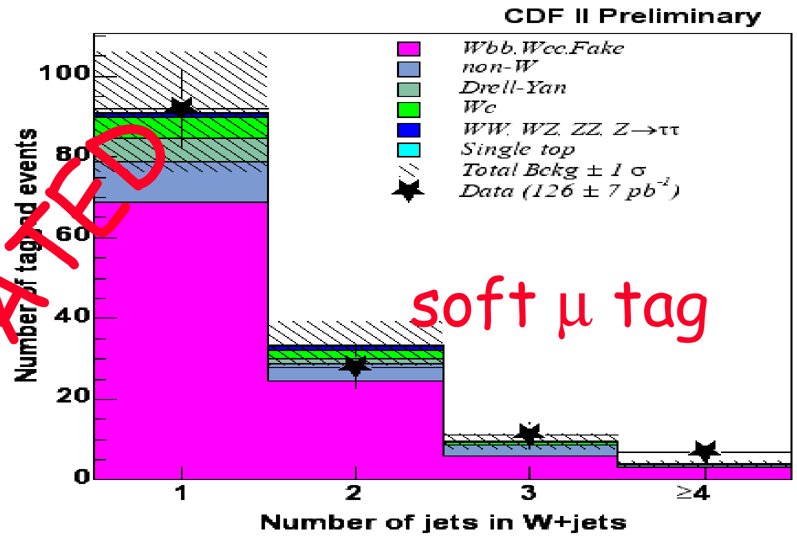
Look for top content in W+jets sample

SLT

kinematic

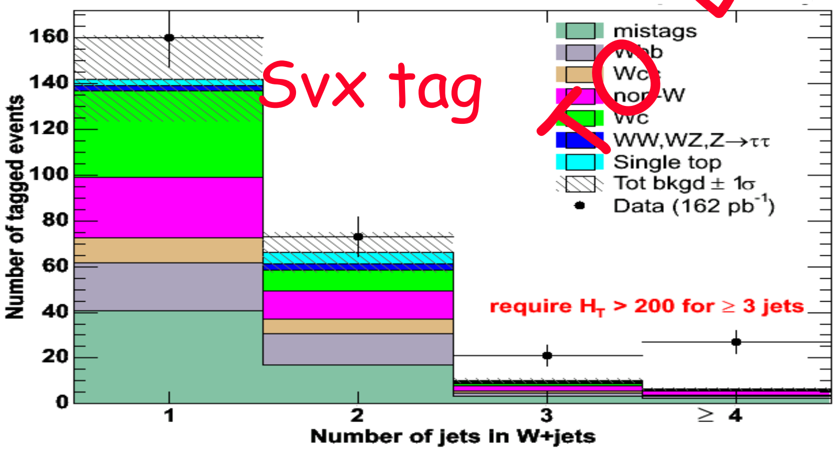


soft μ tag

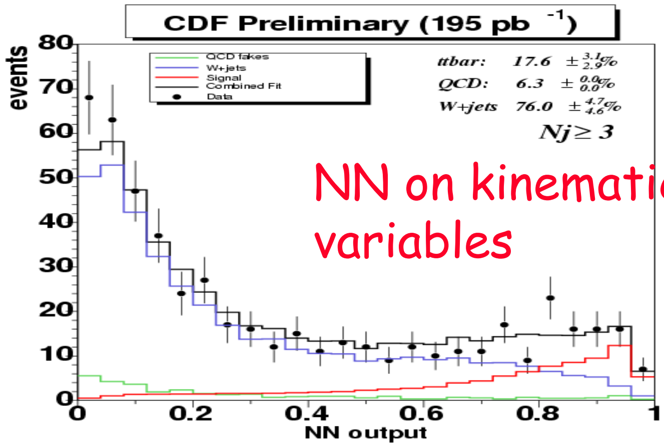


TO BE UPDATED

Svx tag



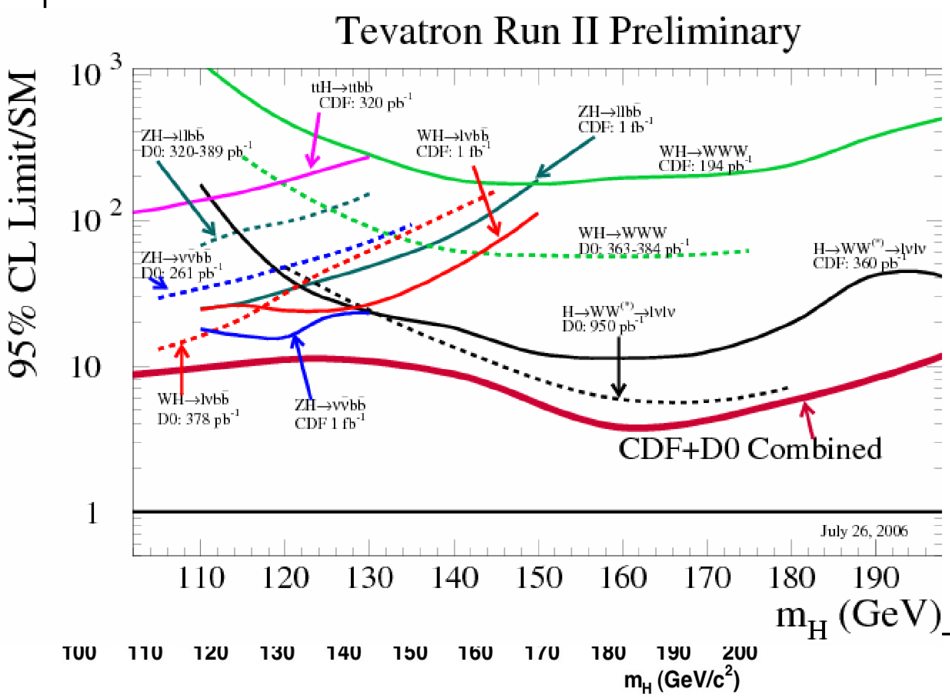
NN on kinematic variables



CDF and D0, 1 fb^{-1}

ICHEP 06

m_H (GeV)	Limit/SM Exp.	Obs.
115	7.6	10.4
130	10.1	10.6
160	5.0	3.9
180	7.5	5.8



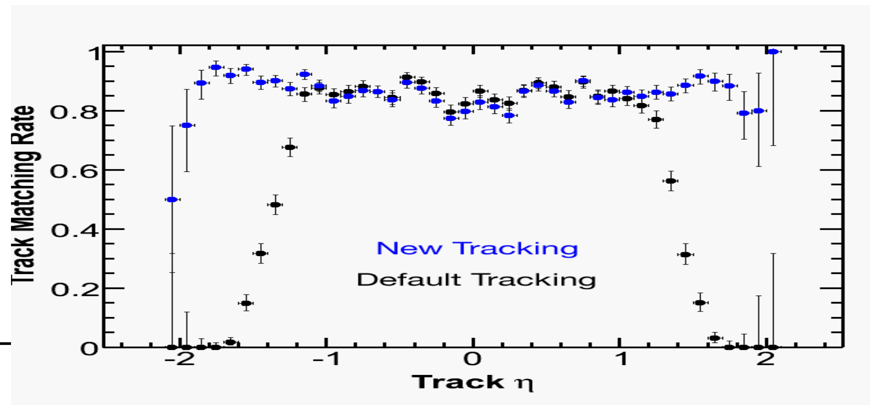
Can we improve?

- ☞ Optimize selection
  - ⇨ Better tools
- ☞ Optimization of b tagging
- ☞ Z→bb (energy scale)
- ☞ Tracking..

Un esempio concreto

⇨ "Default tracking" capito (misure fisica)

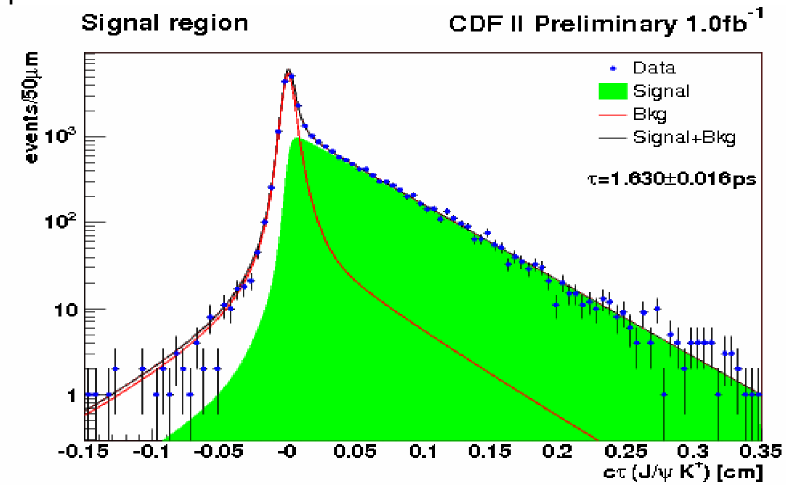
→ Abbiamo capito come riguadagnare eff

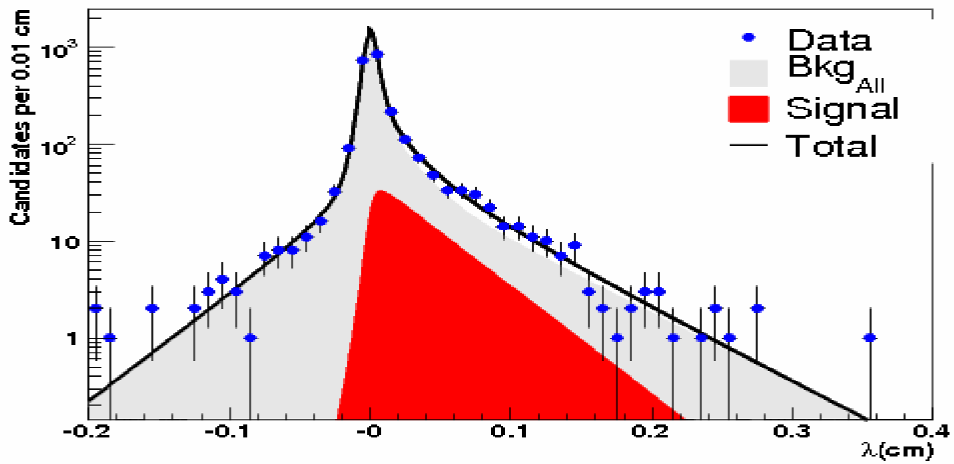


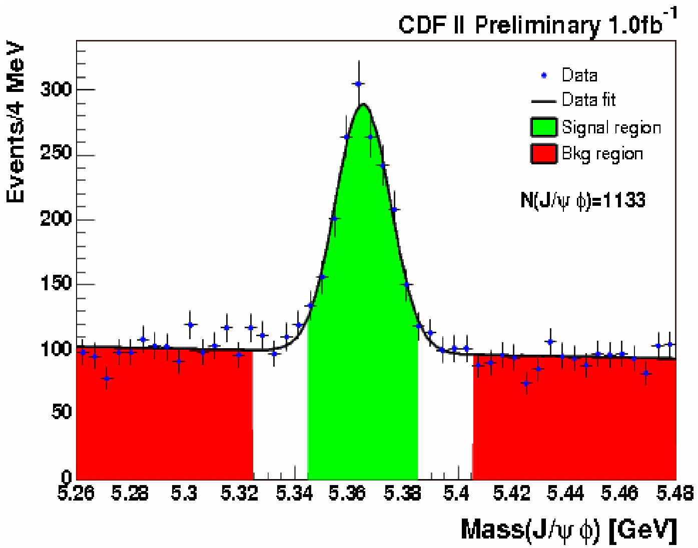
B Physics/Lifetimes

CDF: fit to mass and lifetime

D0: Λ_B in exclusive







B hadron	CDF measurement	
B^+	1.630±0.016(stat.)± 0.011 (syst.)	
B^0	1.551±0.019(stat.)±0.011 (syst.)	
Λ_b	1.580±0.077(stat.)±0.012 (syst.)	
B_s	1.494±0.054(stat.)±0.009	

$\tau(B^+)/\ \tau(B^0)$ = 1.051 ± 0.023 ± 0.004 (syst.)

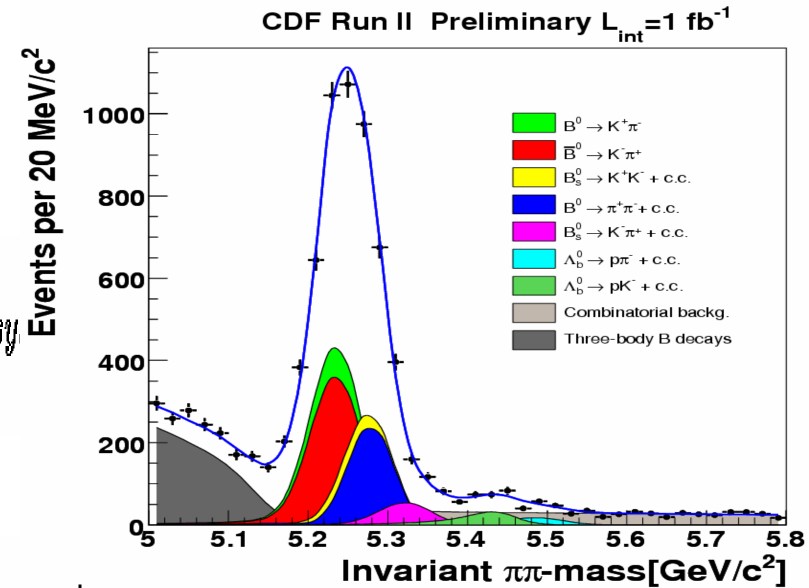
$\tau(B_s)/\ \tau(B^0)$ = 0.963 ± 0.047 ± 0.005 (syst.)

$\tau(\Lambda_B)/\ \tau(B^0)$ = 1.018 ± 0.062 ± 0.007 (syst.)

Rare decays

Trigger capability on B→ hh allows study of rare decays

$$A_{CP} = \frac{N(\overline{B}^0 \to K^-\pi^+) - N(B^0 \to K^+\pi^-)}{N(\overline{B}^0 \to K^-\pi^+) + N(B^0 \to K^+\pi^-)} = -0.086 \pm 0.023\,(stat.) \pm 0.009\,(sy$$

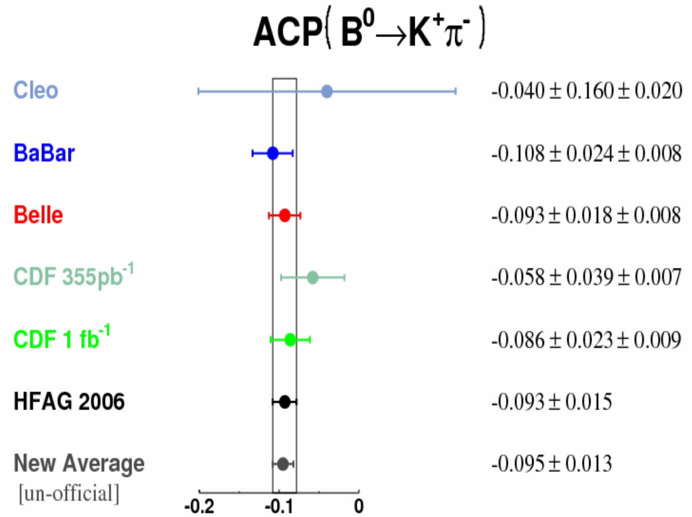


☞ For the first time measured

$$BR(B_s^0 \to K^-\pi^+) = (5.0 \pm 0.75\,(stat.) \pm 1.0\,(syst.)) \times 10^{-6}$$

and its ACP:

$$A_{CP} = \frac{N(\overline{B}_s^0 \to K^+\pi^-) - N(B_s^0 \to K^-\pi^+)}{N(\overline{B}_s^0 \to K^+\pi^-) + N(B_s^0 \to K^-\pi^+)} = 0.39 \pm 0.15\,(stat.) \pm 0.08\,(syst.)$$

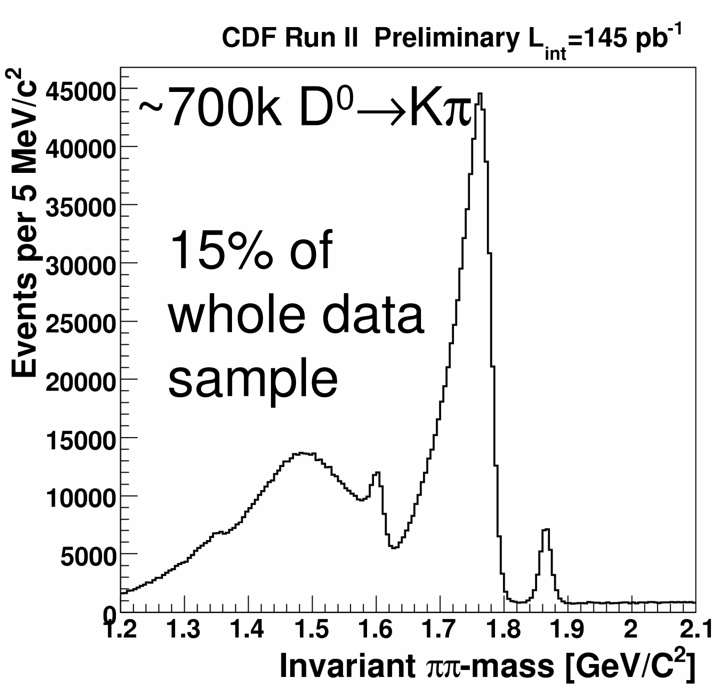


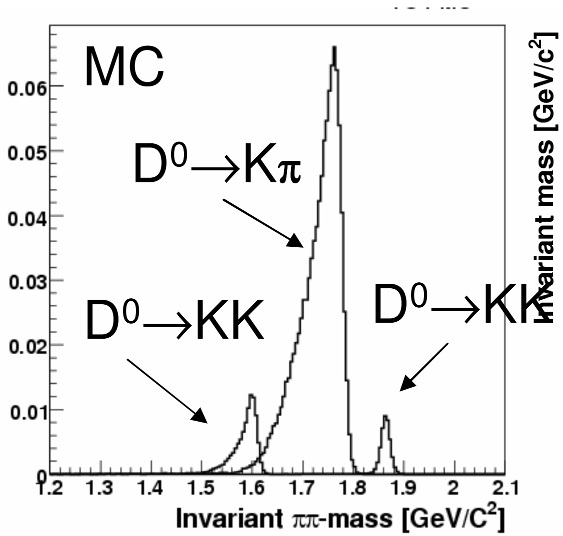
Testing the SM in this sector?

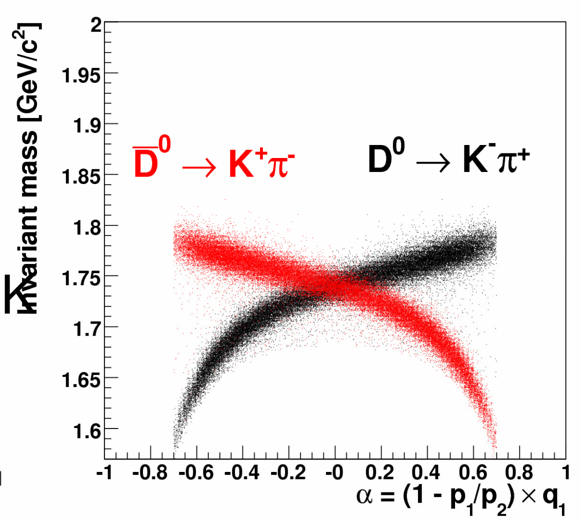
Systematics: $A_{CP}(B^0 \to K\pi)$

source	shift wrt centra
mass scale	0.0004
asymmetric momentum-p.d.f	0.0001
dE/dx	0.0064
input masses	0.0054
combinatorial background model	0.0027
momentum background model	0.0007
MC statistics	—
charge asymmetry	0.0014
$\Delta\Gamma_s/\Gamma_s$ Standard Model	—
lifetime	—
isolation efficiency	—
XFT-bias correction	—
TOTAL (sum in quadrature)	**0.009**

$A_{CP}(D^0 \to K^- \pi^+)$







MC: ($M\pi\pi$ vs α)

Using the same analysis strategy of Bhh we fit the direct $A_{CP}(D^0 \to K\pi)$ which is expected to be very small in the SM and used it to check our understanding of charge biases. Already the kinematics separates D^0 from antiD^0. We measured:

$$A_{CP} = \frac{N_{raw}(\overline{D}^0 \to K^+\pi^-) \cdot \frac{\varepsilon(K^-\pi^+)}{\varepsilon(K^+\pi^-)} - N_{raw}(D^0 \to K^-\pi^+)}{N_{raw}(\overline{D}^0 \to K^+\pi^-) \cdot \frac{\varepsilon(K^-\pi^+)}{\varepsilon(K^+\pi^-)} + N_{raw}(D^0 \to K^-\pi^+)} = -0.00059 \pm 0.00136\ (stat.) \pm 0.0022\ (syst). \qquad (22)$$

Only kinematic fit

Cross-check of $D^0 \to K\pi$ asymmetry with dE/dx

To check the dE/dx systematics we performed an A_{CP} fit on a $D^0 \to K\pi$ sample. We did two fits :kinematic-only and dE/dx-only.

Kinematic-only

$$\frac{N_{\rm raw}(\overline{D}^0 \to K^+\pi^-) - N_{\rm raw}(D^0 \to K^-\pi^+)}{N_{\rm raw}(\overline{D}^0 \to K^+\pi^-) + N_{\rm raw}(D^0 \to K^-\pi^+)} = 0.00823 \pm 0.00136$$

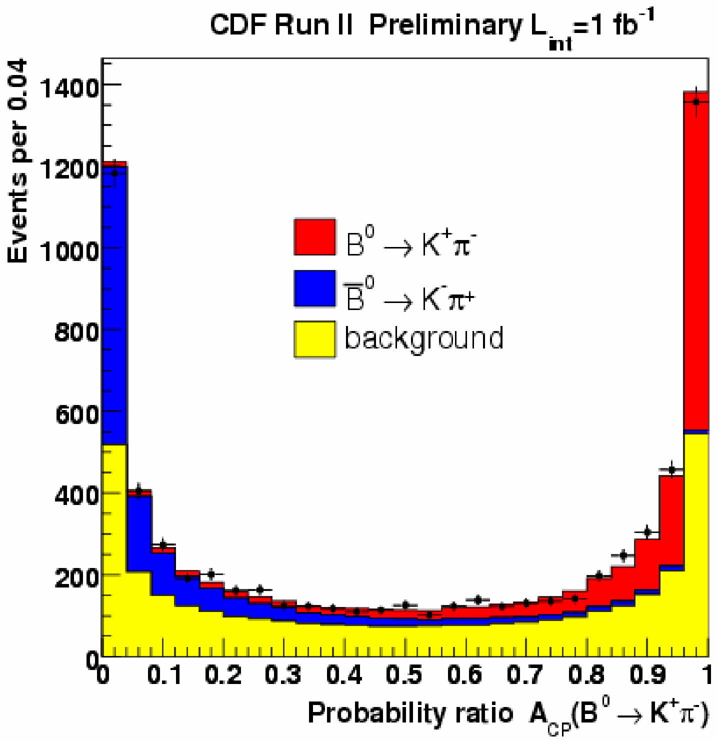
dE.dx-only

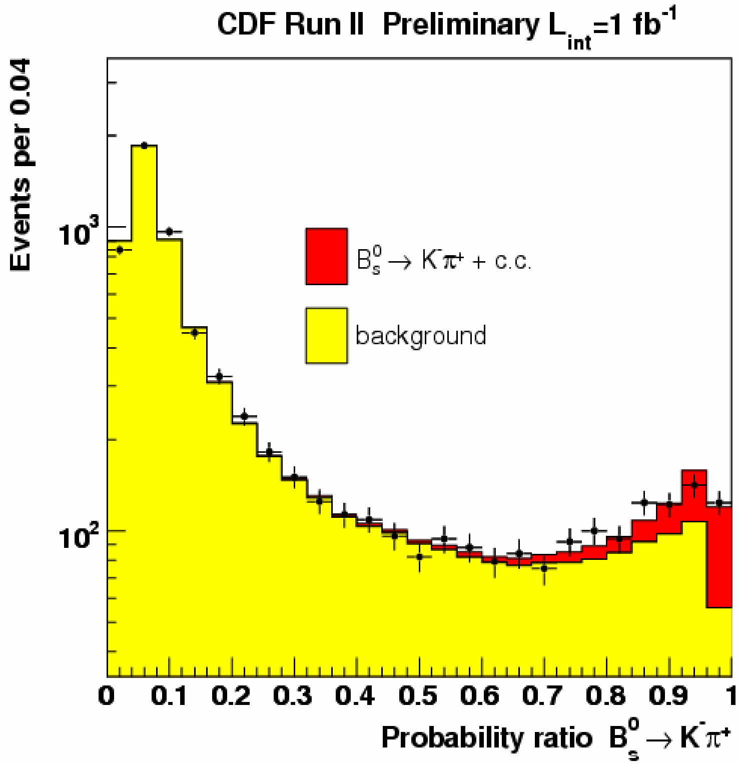
$$\frac{N_{\rm raw}(\overline{D}^0 \to K^+\pi^-) - N_{\rm raw}(D^0 \to K^-\pi^+)}{N_{\rm raw}(\overline{D}^0 \to K^+\pi^-) + N_{\rm raw}(D^0 \to K^-\pi^+)} = 0.00207 \pm 0.00157$$

In the $D^0 \to K\pi$ we obtain A_{CP}(kine)-A_{CP}(dE/dx) = 0.00616

The discrepancy between the two fits is within our quoted dE/dx systematics on direct $A_{CP}(B^0 \to K\pi)$: 0.0064.

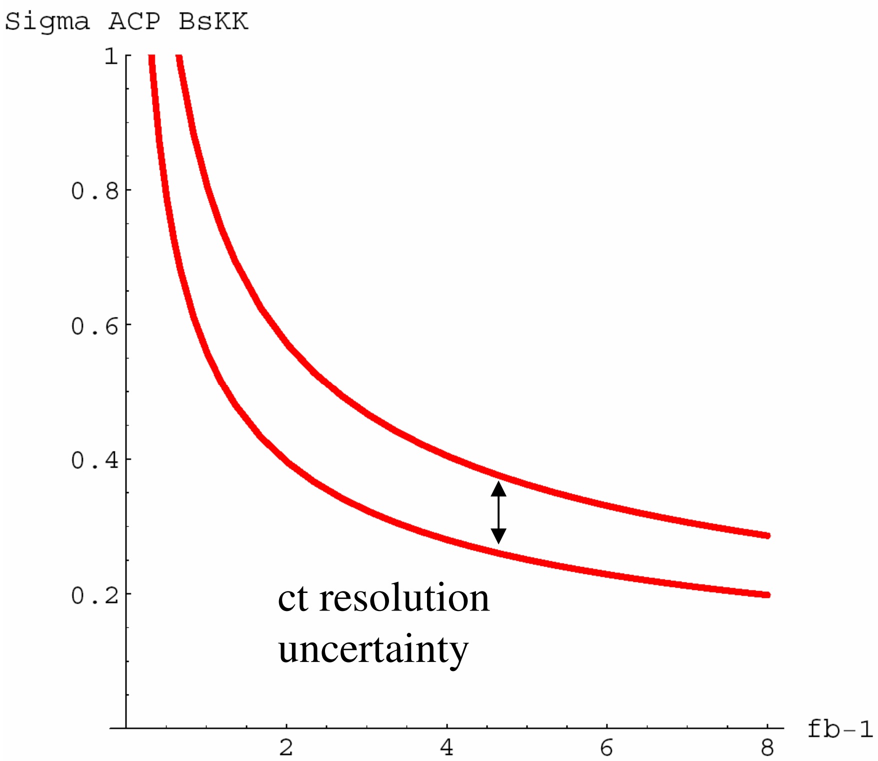
Probability ratio for $A_{CP}(B^0 \rightarrow K^+\pi^-)$ and $B^0_s \rightarrow K^-\pi^+$

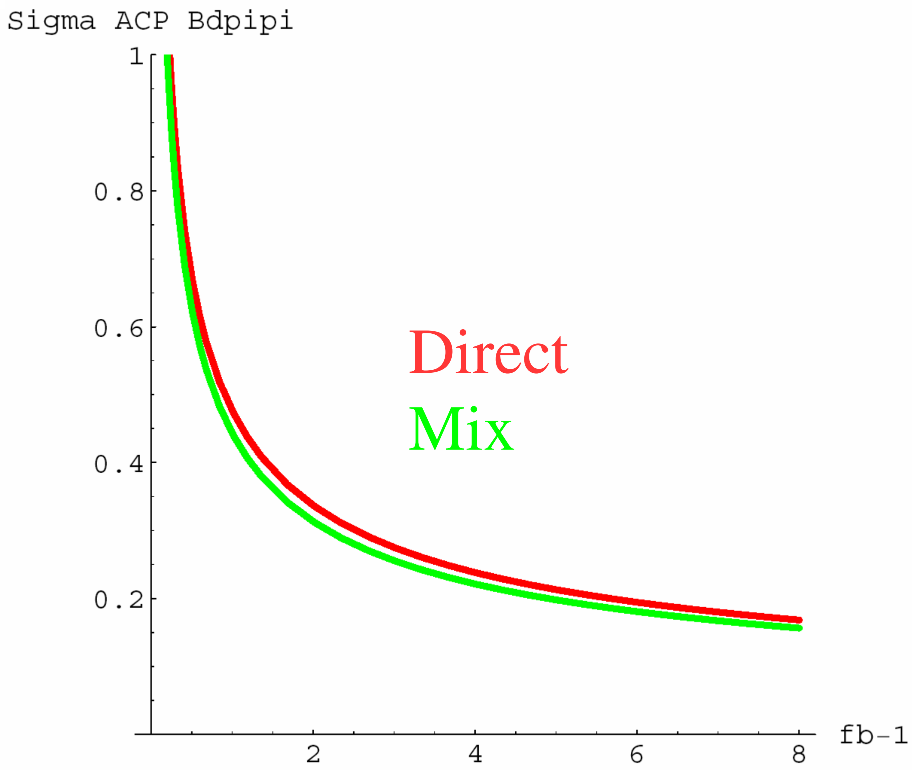




$$\frac{pdf(B_dK\pi)}{pdf(B_dK\pi) + pdf(antiB_dK\pi)} \qquad \frac{pdf(B_sK\pi)}{pdf(B_sK\pi) + pdf(\text{other signals+bckg})}$$

Expectations for Bs→K^+K^- asymmetries



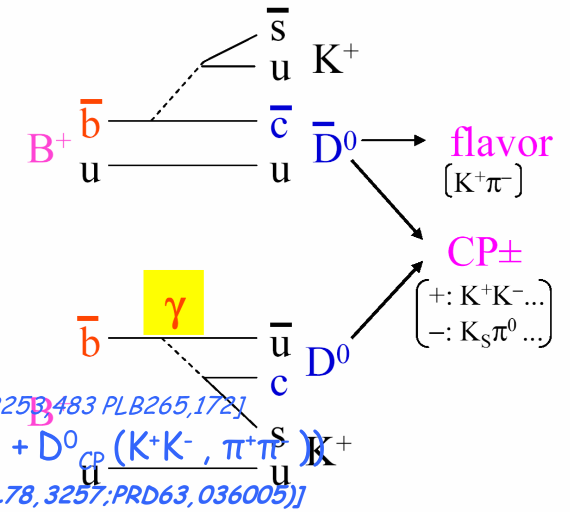


Combining Bs->KK and Bd->ππ asymmetries lead to a determination of γ via flavor-SU(3) relationship (see next)

Measurement of γ at tree-level

Asymmetries in $B^+ \to D^0 K^+$ are a very theoretically clean way to measure γ (1%)
This is a reference quantity for comparing other γ determinations in search for NP

Several methods, depending on D^0 modes:



GLW *[PLB253,483 PLB265,172]*
(D^0_{flav} ($K^+\pi^-$) + D^0_{CP} (K^+K^- , $\pi^+\pi^-$))

ADS *[PRL78,3257;PRD63,036005)]*
(D^0_{flav} ($K^+\pi^-$) + D^0_{DCS} ($K^-\pi^+$))

Dalitz *[PRL78,3257, PRD68,054018]*
($D^0 \to K^0_S\pi^+\pi^-$)

Measurements exist at B factories for all 3

CDF can do the same measurements; in addi tagging)

Gronau PLB 557, 198: Extract γ from

$$R_{CP\pm/\mathrm{flav}} \equiv 2\frac{\sum_{B^+,B^-}\Gamma\left(B\to D^0_{CP\pm}K\right)}{\sum_{B^+,B^-}\Gamma\left(B\to D^0_{\mathrm{flav}}K\right)}$$

Ratio between amplitudes:

$$r_{DK} \equiv \frac{|A(b\to u)|}{|A(b\to c)|} \sim 0.1-0.2$$

$$= 1 + r_{DK}^2 + 2r_{DK}\cos\gamma\cos\delta$$

$$A_{CP\pm} \equiv \frac{\Gamma\left(B^-\to D^0_{CP\pm}K^-\right) - \Gamma\left(B^+\to D^0_{CP\pm}K^+\right)}{\ldots \quad + \quad \ldots}$$

$$= \pm 2 r_{DK}\sin\gamma\sin\delta / R_{CP+}$$

Measure for each D →f:

$$R_f^{K/\pi} \equiv \frac{\sum_{B^+,B^-}\Gamma\left(B\to D^0_f K\right)}{\sum_{B^+,B^-}\Gamma\left(B\to D^0_f \pi\right)}$$

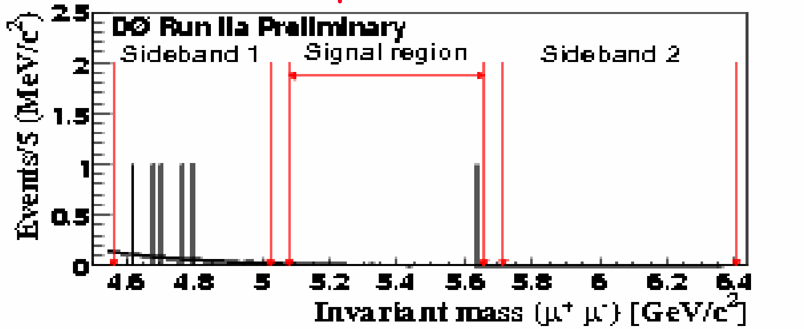
Then $R_{CP\pm/\mathrm{flav}} = R^{K/\pi}_{CP\pm} / R^{K/\pi}_{\mathrm{flav}}$

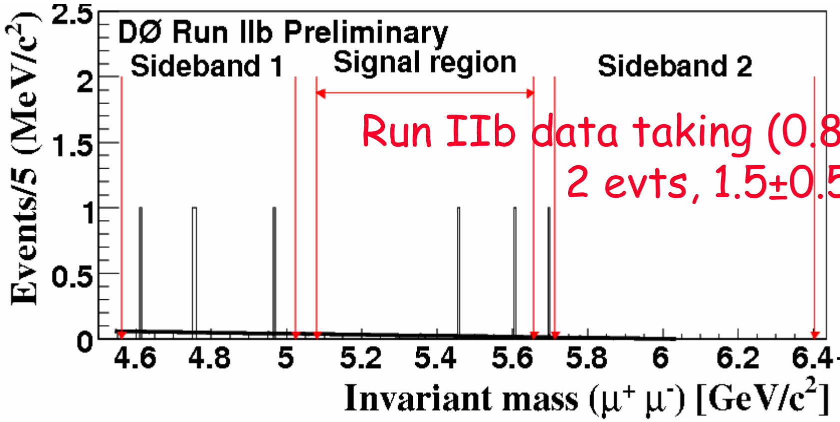
Bd, Bs→ μμ rare decays

D0 new result with 2 fb^{-1}

- 3 events (2.3+-0.7 exp.)
- <9.3(7.5)10^{-8}@95(90)% CL
- Not yet combined with CDF

Run IIa data taking (1.3 pb^{-1})
1 evts, 10.8±0.2 exp

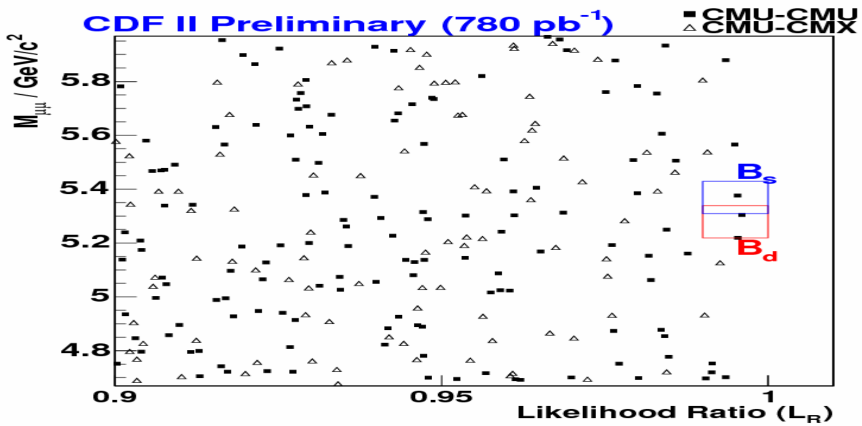




Run IIb data taking (0.8 pb-
2 evts, 1.5±0.5 ex

CDF searches for B_s and B_d decays into dimuons

- Expected at O(10^{-9}) level
- 0.8 fb-1 CL limits:
  - ⇨ B_s<10(8) 10^{-8} 95(90) %
  - ⇨ B_d<2.3(2) 10^{-8} 95(90) %
  - ⇨ To be updated soon..

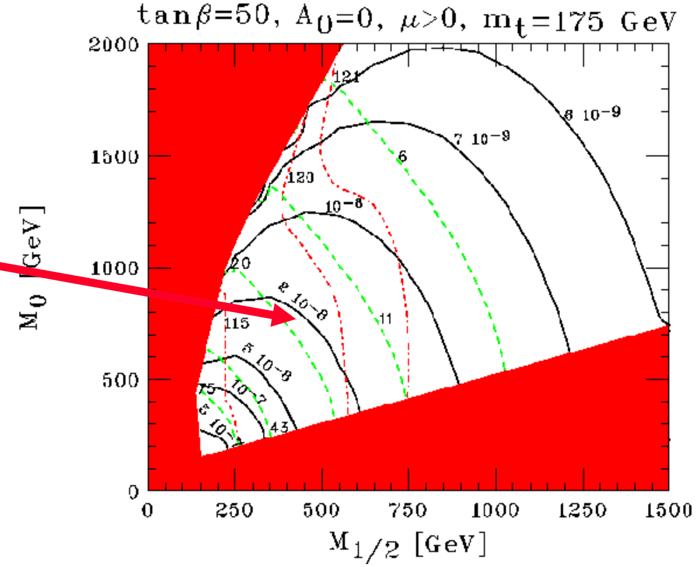


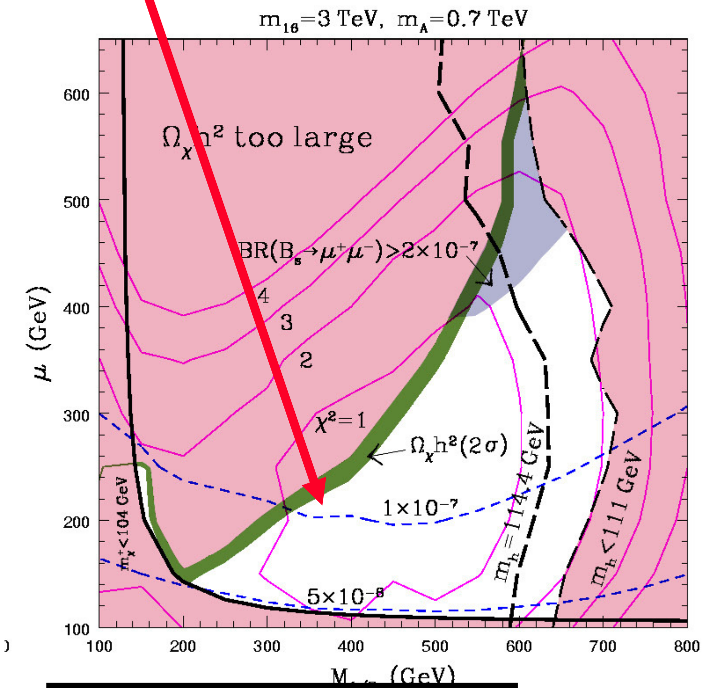
G

SUSY limits-examples

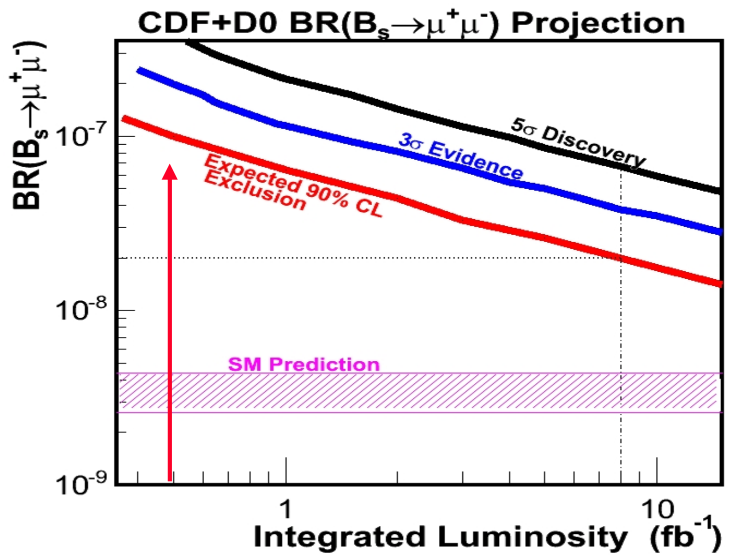
B_d 2.3(2) 10^{-8}@95(90)%CL,

B_s<9.3(7.5) 10^{-8} @95 (90)% CL



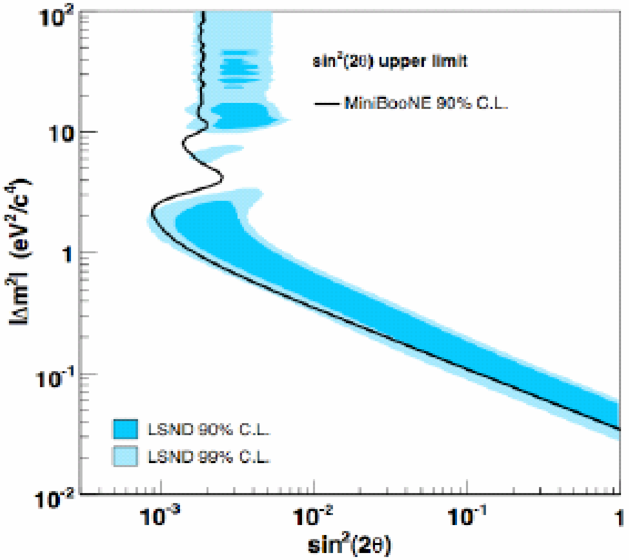


R. Dermisek *et al.*,
hep-ph/0507233 (2005)



MiniBoone

The result of
the $\nu_\mu \rightarrow \nu_e$ appearance-only analysis
is a <u>limit</u> on oscillations:



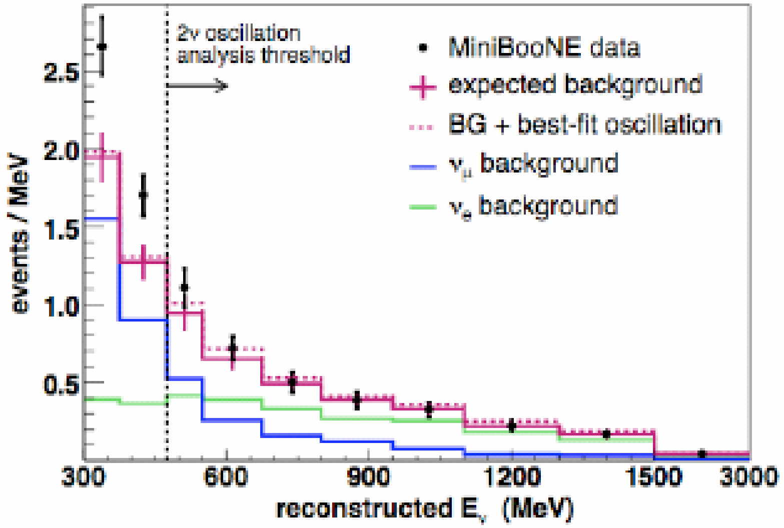
χ^2 probability,
null hypothesis: 93%

Energy fit: $475 < E_\nu^{QE} < 3000$ MeV

Miniboone

As planned before opening the box....

Report the full range:
$300 < E_\nu^{QE} < 3000$ MeV



$96 \pm 17 \pm 20$ events above background, for $300 < E_\nu^{QE} < 475$MeV

Deviation: 3.7σ

Background-subtracted: